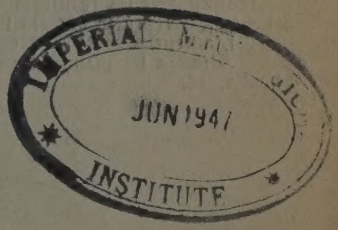
COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

NOUVELLE SÉRIE

1944



VOLUME XLV

№ 1

ÉDITION DE L'ACADÉMIE DES SCIENCES DE L'URSS
MOSCOU

AVIS AUX AUTEURS

Les «Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS» paraissent tous les dix jours. Neuf numéros composent un volume pourvu d'une table des matières. Il y a quatre volumes par année.

Les «Comptes Rendus de l'Académie des Sciences de l'URSS» en de courtes communications précisent l'essentiel des travaux en préparation. Ces articles, ne dépassant pas en règle générale quatre pages, sont donnés en anglais, en français ou en allemand. Ils embrassent les sciences mathématiques, physiques, naturelles et appliquées, mettant au jour les résultats de recherches scientifiques en cours ou qui viennent d'être achevées, et représentant ainsi les plus récentes données de l'investigation scientifique.

L'auteur a droit à 50 exemplaires de son article.

Adressez les manuscrits à la Rédaction des «Comptes Rendus», Moscou, Wolkhonka, 14.

10 Octobre

COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

COMITÉ DE RÉDACTION

A. **Arbusov**, de l'Académie, V. **Chlopin**, de l'Académie, A. **Deborin**, de l'Académie, A. **Fersman**, de l'Académie, A. **Frumkin**, de l'Académie, A. **Kolmogoroff**, de l'Académie (vice rédacteur), L. **Orbeli**, de l'Académie (rédacteur en chef), A. **Richter**, de l'Académie, S. **Soboleff**, de l'Académie, S. **Wawilow**, de l'Académie (vice rédacteur)

NOUVELLE SÉRIE

12-me année

Paraissant tous les dix jours

1944

VOLUME XLV, № 1

TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

A. D. Alexandroff. The Inner Metric of a Convex Surface in a Space of Constant Curvature 3

PHYSIQUE

S. I. Wawilow, Member of the Academy. A Remark on the Theory of Concentration Quenching of Fluorescence in Solutions 7

A. A. Glagoleva-Arkadieva. Principal Waves in the Spectrum of the Mass Radiator 10

PHYSIQUE APPLIQUÉE

F. Molero. A New Method of Making Large Mirror Paraboloids for the Industrial Utilization of Solar Energy 14

CHIMIE

N. D. Zelinsky, Member of the Academy, and J. A. Arbusov. Contact Isomerization of Cycloheptene 19

CHIMIE DU GLOBE

S. S. Smirnov, Member of the Academy. On the Concentrations of Boron in the North-Eastern Ore Province 22

CHIMIE APPLIQUÉE

G. N. **Masliansky**. Desulphurization of Benzines on a Nickel Catalyst 24

CYTOLOGIE

G. G. **Tiniakov** and A. P. **Tiniakova**. A Contribution to the Aceto-Carmine Technique 27

GÉNÉTIQUE

B. A. **Kirssanow**. Translocation Process in Inert and Active Regions of Chromosomes in *Drosophila melanogaster* 31

PHYSIOLOGIE VÉGÉTALE

S. W. **Bulgakov**. Modified Anatomical Structure in Kok-saghyz Roots and its Biological Import 35

MORPHOLOGIE EXPÉRIMENTALE

R. **Kohan**. The Chordomesoderm as an Inductor of the Ear Vesicle 39

A. **Rumjantzew** and L. **Berezkina**. Development of Bone Tissue in Pure Cultures of Osteogenic Mesenchyme *in vitro* 42

Edition de l'Académie des Sciences de l'URSS
Moscou 1944

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

MATHEMATICS

THE INNER METRIC OF A CONVEX SURFACE IN A SPACE OF CONSTANT CURVATURE

By A. D. ALEXANDROFF

(Communicated by I. M. Vinogradow, Member of the Academy, 21. III. 1944)

1. If a convex body is defined as a closed set with inner points possessing the property to contain the shortest line connecting any pair of its points, this definition will be valid in any Riemann space. Under a convex surface we understand a region on the boundary of a convex body; the whole boundary of a convex body of finite size is called a closed convex surface.

We shall consider convex surfaces in three-dimensional simply connected spaces of constant curvature. Such a space with the curvature K we shall call the space of curvature K. K being <0, this space is that of Lobachevsky; K being $=0$, it is Euclidian; K being >0, it is spherical.

For the distance $\rho(X\,Y)$ between two points X, Y on a surface F we take the greatest lower bound of the lengths of all the curves lying on F and connecting X and Y. If two arbitrary points of the surface F can be connected on F by a curve with the finite length, then thus defined distance exists for every pair X, Y of points of the surface F and represents the inner metric of the surface F. Thus, F becomes a metric space with the metric $\rho(X\,Y)$.

It is easy to prove that on every convex surface any two points can be connected by a curve of the finite length, and, therefore, every convex surface possesses an inner metric.

The problem consists in establishing those conditions which characterize the inner metric of convex surfaces in a space of arbitrary curvature, *i. e.* the necessary and sufficient conditions that a given metric space be isometric to a convex surface.

In this paper we give the necessary conditions characterizing the metric of any convex surface (Theorem 3) and establish their sufficience «in the small» (Theorem 4) and «in the large» for closed convex surfaces (Theorem 5). The results concerning the open complete convex surfaces will be established in another paper.

Such surfaces exist in the spaces of non positive curvature only.

The conditions which define the metric of a convex surface in the Euclidian space were given by me in a previous paper [1]. The results established in the present paper are analogous to those of the paper [1], though some simplifications are made for the case of Euclidian space in the comparison to [1]. No proofs are given here; they are analogous to those for the case of Euclidian space.

2. Further, when speaking about the straight lines and planes, we mean those of the space of constant curvature.

Complete convex surfaces include among themselves «twice covered» plane convex regions together with their boundaries* (the whole plane is excluded).

* The rigorous definition may be found in [2].

X and Y being two points on opposite sides of the region, the distance between them is defined by means of curves proceeding from X to the boundary of the region and further to Y. Twice covered finite convex region is considered as a closed convex surface.

Any region on such a degenerate complete surface may be considered as a convex surface.

3. We begin with the characterization of the matrix of closed convex polyhedrons.

By a cone we understand a surface generated by the segments drawn from a point O (the vertex of the cone) to all the points of a rectifiable closed curve not containing O. The whole angle at the vertex of a cone is understood to mean that angle which is covered by the cone when it is cut along one of its generatrices and unfolded on the plane.

Theorem 1. *In order that a metrical space R be isometric to a convex closed polyhedron in the space of the curvature K, it is necessary and sufficient that*: 1) *R be homeomorphic to a sphere*; 2) *each point of R possess a neighbourhood isometric to a cone (in a space of curvature K) with the whole angle at the vertex $\leqslant 2\pi$*; 3) *the distance between any two points in R be equal to the greatest lower bound of the lengths of the curves connecting these points**.

In the case of Euclidian space this theorem, though put in another form, has been proved in ([1]). The proof for the space of arbitrary curvature is quite the same; only some details require some modifications.

4. Theorem 2. *A line element with the curvature $\geqslant K$ being given on a sphere, in the space of curvature K there exists a closed convex surface realizing the metric defined on the sphere by the given line-element.*

The proof does not differ from that given in ([1]) for the case $K=0$.

5. In order to express the conditions characterizing the metric of an arbitrary convex surface, some definitions must be introduced.

Let R be a metric space with the metric ρ. The length of the curve $X(t)$ in $R (0 \leqslant t \leqslant 1,\ X(t) \in R)$ is defined as usual, *i. e.* as the least upper bound of the sums

$$\sum_{i=1}^{n} \rho(X(t_{i-1}) X(t_i))$$

where $0 = t_0 < t_1 < \ldots < t_{n-1} < t_n = 1$.

The metric ρ of the space R we call inner metric, if for each pair of points $X, Y \in R$ $\rho(XY)$ is the greatest lower bound of the lengths of the curves connecting X and Y.

It is easy to prove the following statement:

Let a metric ρ_0 be given on a set R. Define by means of this metric another one ρ: $\rho(XY)$ is the greatest lower bound of the lengths of the curves connecting X and Y, these lengths being defined in the metric ρ_0 and the curves being continuous in this metric. The metric ρ thus defined, provided it exists, is inner in the above sense.

On a surface R there is always defined an exterior metric ρ_0, the distance measured in the surrounding space. After ρ_0 we define the inner metric ρ of the surface.

This metric is inner in the sense of the above definition, as it follows from the just formulated statement.

6. The tangent cone to a surface at its point O is the cone generated by the rays which are the limits of the rays proceeding from O through points X of the surface, while X approach O.

Let R be a metric space with the metric ρ, O be a point of R and C be a cone with the inner metric ρ'. We say that the cone C is tangent to R

* The length of the curve in R is defined in an evident way in virtue of the condition 2. General definition of the length in any metric space is recalled in n. 5.

or to its metric ρ at the point O, if there exists a mapping h of the neighbourhood of O into the cone C, which is subject to the following conditions: 1) h is a homeomorphism; 2) h, image of O, is the vertex of the cone C; 3) for every $\varepsilon > 0$ there exists such a $\delta > 0$ that

$$|\rho(XY) - \rho'[h(X)\,h(Y)]| < \varepsilon[\rho(OX) + \rho(OY)]$$

whenever $\rho(OX)$ and $\rho(OY)$ are less than δ.

It can be proved:

The tangent cone to a convex surface at any of its points is tangent to its inner metric at this point (for the map h, mentioned in the definition of the cone tangent to a metric, a projection from any inner point of the cone may be taken).

7. We shall say that the metric ρ defined on a set R is convex relatively to the metric of the curvature K if for every point $O \in R$ there exists such an $\varepsilon > 0$ that, whenever $\rho(OX)$, $\rho(OY)$, $\rho(OZ)$ are $< \varepsilon$, the following condition is fulfilled.

Let the points Y_1, Z_1 be such that

$$\rho(XY_1) = \rho(Y_1Y) = \frac{1}{2}\rho(XY)$$

$$\rho(XZ_1) = \rho(Z_1Z) = \frac{1}{2}\rho(XZ)$$

Consider the triangle on the plane in the space of the curvature K, the sides of which are equal to $\rho(XY)$, $\rho(XZ)$, $\rho(YZ)$. Let d denote the length of the segment connecting the midpoints of the sides equal to $\rho(XY)$, $\rho(XZ)$.

Then

$$\rho(Y_1Z_1) \geqslant d$$

If $K = 0$, then $d = \frac{1}{2}\rho(YZ)$ and the condition is reduced to

$$\rho(Y_1Z_1) \geqslant \frac{1}{2}\rho(YZ)$$

It is possible to prove that the inner metric of every convex surface in the space of the curvature K is convex with respect to the metric of the curvature K. And even more: *Let X, Y, Z be three points on a convex surface (arbitrary if the surface is complete, and lying in a suitable neighbourhood of any point if the surface is not complete). Let $0 < s < 1$, and $0 < t < 1$, and the points Y_s, Z_t be such that*

$$\rho(XY_s) = s\rho(XY), \quad \rho(Y_sY) = (1-s)\rho(XY)$$

$$\rho(XZ_t) = t\rho(XZ), \quad \rho(Z_tZ) = (1-t)\rho(XZ)$$

*where ρ is the inner metric of the surface. Consider the triangle of the plane with the sides equal to $\rho(XY)$, $\rho(XZ)$, $\rho(YZ)$ in the same space where the surface lies. Let a be the length of the segment connecting the points which divide the sides equal to $\rho(XY)$ and $\rho(XZ)$ in the ratio $s:(1-s)$ and $t:(1-t)$. Then $\rho(Y_sZ_t) \geqslant a$**.

---

* This result can be refined as follows. Let x, y be two geodesics (*i. e.* shortest lines between their end points) running from one and the same point O on a convex surface. Let X, Y be variable points on x and y, and $\xi = \rho(OX)$, $\eta = \rho(OY)$, $\zeta = \rho(XY) = f(\xi, \eta)$. Construct on the plane the triangle with the sides equal to ξ, η, ζ and consider its angle opposite to the side ζ. This angle is the function of ξ, η and we prove that it is the non-increasing function of ξ and η [$\gamma(\xi, \eta) \leqslant \gamma(\xi_1, \eta_1)$], provided that $\xi \geqslant \xi_1$, $\eta \geqslant \eta_1$ (it is decreasing except the case when the triangle OXY is isometric to a plane one). It is easy to see that the statement made in the text is a corollary of this one.

The following theorem seems to be worth mentioning:

A metric defined by means of a line-element with twice differentiable coefficients is convex relatively to the metric of the curvature K if and only if the Gaussian curvature of the given line-element is nowhere less than K.

8. Summing up the statements made in 5—7 we obtain:

Theorem 3. *In order that a metric space be isometric to a convex surface in the space of the curvature K, the following conditions are necessary:* 1) *the metric of the space must be inner;* 2) *at every point it must possess a tangent cone;* 3) *it must be convex relatively to the metric of the curvature K* (that the space is a two-dimensional manifold follows evidently from the conditions 1 and 2).

How far these conditions are sufficient is seen from the following two theorems.

Theorem 4. *If a metric space satisfies the conditions of Theorem 3, then every its point has a neighbourhood isometric to a convex surface in the space of curvature K.*

Theorem 5. *A metric space which satisfies the conditions of Theorem 3 and is homeomorphic to a sphere is isometric to a closed convex surface in the space of curvature K.*

The idea of the proof of Theorems 3, 4, 5 is very simple. Theorem 3 is proved, at first, for the convex polyhedrons and then by proceeding to the limit extended to every convex surfaces. In order to prove Theorem 5 we approximate the metric of the given metrical space by means of polyhedral convex metrics (*i. e.* metrics subject to the conditions of Theorem 1), and, realizing these metrics by means of the convex polyhedrons, which is possible in virtue of Theorem 1, we choose from these polyhedrons a convergent series, the limit of which gives us the surface isometric to the given space.

Stekloff Mathematical Institute.
Academy of Sciences of the USSR.

Received
21.III.1944.

REFERENCES

[1] A. D. Alexandroff, C. R. Acad. Sci. URSS, XXX, No 2 (1941).
[2] A. D. Alexandroff, Rec. Math., 11 (53), 15 (1941).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

PHYSICS

A REMARK ON THE THEORY OF CONCENTRATION QUENCHING OF FLUORESCENCE IN SOLUTIONS

By S. I. WAWILOW, Member of the Academy

1. Within the last years the author in a series of papers (1) has worked out a general theory of the influence which the concentration of a fluorescent compound in solution is known to have upon such properties of the fluorescence as polarization, yield and duration of light emission. This theory is based upon the assumption that the excited molecule is in resonance with its unexcited neighbours, and the natural result of this state of affairs is a transfer of excitation from one dissolved molecule to another *. Quantitatively this interpretation accounts satisfactorily both for the «concentration» depolarization and for the «decay» depolarization (2).

The resonance nature of quenching by concentration is suggested by the likeness between quenching curves and depolarization curves. Yet to explain the quenching in terms of the resonance some added assumptions are necessary. The credit for being the first to advance the resonance theory of quenching by concentration belongs to Dushinsky (3). He proceeded, however, upon the case where there is another molecule in close proximity to the excited one (associated molecules furnishing here a representative instance). And in addition to this he also made several other restrictive assumptions.

Quantitatively the theory of Dushinsky is sharply at variance with the experiment.

In the present author's theory the conditions under which quenching take place are not specified. No qualifying statements are made beyond the general assumption that there is a finite probability for resonance transfers of excitation energy, which varies with time t and concentration c, and, generally speaking, does not vanish even when $t = 0$. For the probability of the absence of resonance transfers with quenching we find (in first approximation) the expression

$$w(c, t) = e^{-\omega_0 c e^{-ct/k_1}} \qquad (1)$$

and may express the probability for the absence of transfers without quenching as

$$q(c, t) = e^{-\lambda_0 c e^{-ct/k_2}} \qquad (2)$$

The general form (1) covers a great variety of conditions. But one known case, however, fails to come under its scope. This case being simple and inevitable, whenever there is resonance, we ought to consider it in some detail.

2. It is known that the quantum output of fluorescence in solutions is in the majority of cases below unity even with vanishingly small concentrations (4).

* Owing to a great deal of simplification the theory as exposed in the above-mentioned papers does not extend beyond the range of small concentrations. A more rigourous theory will be developed elsewhere.

This points to the existence of an internal quenching independent of t or c.

Denote by g the probability for the absence of internal quenching in the case of direct absorption of light. The excitation energy will in general be smaller than the absorption energy (Stokes' law), and therefore the probability for the absence of internal quenching f on the subsequent transfers due to resonance may happen to be different from g.

Let us suppose that no other kind of quenching is taking place in the medium besides the internal quenching. And for simplifying the calculations (which in this note are merely intended to serve as illustration) we put λ_0 in formula (2) at zero.

Under these conditions we are to compute the probability of radiation in the successive links involved in the migration of the excitation energy. The probability of spontaneous radiation without transfer of energy is

$$u_1 = \frac{g}{\tau_0} \int_0^\infty e^{-ct/k_2} e^{-t/\tau_0} dt$$

The probability of radiation u_2 for molecules excited by a single transfer may be expressed as follows.

The probability of the excitation energy staying in first molecule (*i. e.* in the one that has absorbed light directly) for a time θ_1 and of its further transfer in the interval between θ_1 and $\theta_1 + d\theta_1$ is

$$g \frac{c}{k_2} e^{-\theta_1 c/k_2} d\theta_1$$

Further, the probability of re-emission by the second molecule during the interval from t to $t+dt$ is

$$\frac{f}{\tau_0} e^{-(t-\theta_1)c/k_2} e^{-t/\tau_0} dt$$

Hence

$$u_2 = \frac{cgf}{\tau_0 k_2} \int_0^\infty \int_0^t e^{-\theta_1 c/k_2} e^{-(t-\theta_1)c/k_2} e^{-t/\tau_0} d\theta_1 \, dt =$$

$$= \frac{cgf}{\tau_0 k_2} \int_0^\infty \int_0^t e^{-t\left(\frac{c}{k_2} + \frac{1}{\tau_0}\right)} d\theta_1 \, dt$$

On the same reasoning we find

$$u_n = \frac{c^{n-1} g f^{n-1}}{\tau_0 k_2^{n-1} (n-1)!} \int_0^\infty t^{n-1} e^{-t\left(\frac{c}{k_2} + \frac{1}{\tau_0}\right)} dt =$$

$$= \frac{g}{f} \frac{k_2}{c\tau_0} \left[\frac{cf}{k_2} \left(\frac{c}{k_2} + \frac{1}{\tau_0} \right)^{-1} \right]^n$$

The total probability of radiation without quenching is represented by the sum

$$U = \sum_{n=1}^{n=\infty} u_n = \frac{g}{f} \frac{k_2}{c\tau_0} \left[\frac{f}{(1-f) + \frac{k_2}{c\tau_0}} \right] \qquad (3)$$

U varies directly as the yield of fluorescence L; but, on the other hand, it is seen from (3) that for $c=0$ we have $U_0 = g$, and, accordingly, L_0 is proportional to g.

Making use of this, the law of concentration quenching for the case considered is obtained in the form

$$\frac{L_0}{L} = 1 + \frac{(1-f)\tau_0}{k_2} c \qquad (4)$$

3. In the case of dye-stuff solutions the actual run of quenching by concentration does not conform to the linear law (4), but the latter must (at least in the form corresponding to the case $\lambda_0 \neq 0$) make a necessary part of a more complex law, whenever there is internal quenching and resonance. It may be remarked, moreover, that in weak solutions of uranyl salts the linear law is obeyed [5].

Two consequences, which lend themselves to experimental verification, can be drawn from the statements made here. In the first place it should be noted that if $f = 1$ and no other factor is present to provoke quenching, then the increase of concentration should bring about a depolarization unattended by quenching.

Secondly, since the considered case of concentration quenching is in the long run determined by the yield of fluorescence upon an infinite dilution, the main constant of quenching can be found from the quantum output of fluorescence within the range of very small concentrations (the operation is particularly simple when $f = g$).

P. N. Lebedev Physical Institute.
Academy of Sciences of the USSR.

Received
15.VIII.1944.

REFERENCES

[1] S. I. Wawilow, Journ. of Physics, **7**, 141 (1943). [2] S. I. Wawilow, C. R. Acad. Sci. URSS. XLII, 344 (1944). [3] F. A. Dushinsky, ibid., XIV, 73 (1937). [4] S. I. Wawilow, ZS. f. Phys., **22**, 266 (1924). [5] S. I. Wawilow u. W. L. Lewschin, ZS. f. Phys., **48**, 397 (1928).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

PHYSICS

PRINCIPAL WAVES IN THE SPECTRUM OF THE MASS RADIATOR

By A. A. GLAGOLEVA-ARKADIEVA

(Communicated by S. I. Wawilow, Member of the Academy, 15.III.1944)

Interference curves obtained by N. A. Sokolov [1] with vacuum resonance thermoelectric couples show that thermocouples with thin open antennas have sufficiently sharp resonance. The resonance curve obtained by A. P. Kalugina [2] with an air resonance thermocouple of the same type and with several mass radiators differing in average length of particles in the vibrational mixture showed that a definite length of the particles in the mixture, vibrating in pairs like small Hertz oscillators, corresponds to the maximum of the curve. This pointed to the possibility of employing thermoelectric couples with thin antennas in the investigation of the radiation intensity distribution in the spectrum of the mass radiator.

If a thermocouple with a galvanometer in its circuit is placed in the focus of a concave mirror to coincide with the image of the radiation source, the galvanometer gives a deflection α, proportional to the intensity of the radiation of the source and the intensity of the reception by the detector of that wave-length λ at which the thermocouple's antenna resonates. Employing a series of thermocouples with different-sized antennas a, we shall get a series of deflections α, characterizing the intensity of the radiation and the reception, each corresponding to a wave of definite length λ in the mixed radiation of the mass radiator. Plotting for each thermocouple against the antenna lengths a the galvanometer deflections α, we get a graph of the function

$$\alpha = f(a) \tag{1}$$

which will characterize the radiation of a vibrational mixture having a constant concentration k and containing metal particles of mean length l. The resonance wave-length λ of a thermocouple is connected with the length of its antenna a by the relation $\lambda/a = n$, where n is a function of the relative dimensions of the antenna. Expression (1) may be written in the form

$$\alpha = \varphi(\lambda) \tag{2}$$

Power P absorbed by a thermocouple as a function of the wave-length may in the case of a plane wave be expressed by the formula

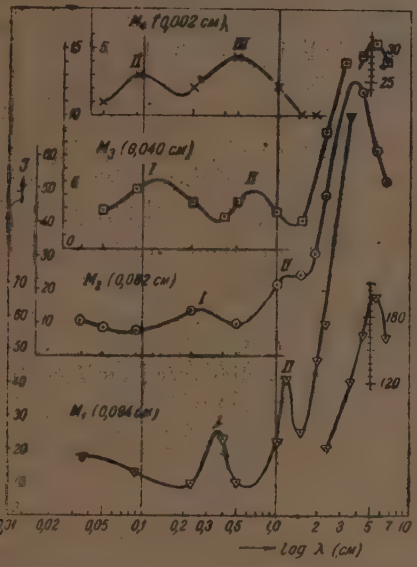
$$P \sim \frac{E^2 a^2 R_a}{(R_a + R_s)^2} \tag{3}$$

where $R_a = \xi(\lambda)$ is the resistance of the antenna to a high frequency current; R_s is the resistance of the radiation; E is the electrical field strength of a wave of given length λ; $a = \lambda/n$.

In this paper we confine ourselves to a consideration of curves of the type of (2).

Apparatus and Measurements. A study was made of the radiation of several radiators M_1, M_2, M_3 and M_4 containing in the mixture metal particles of a mean length l equal to 0.094, 0.082, 0.040 and 0.002 cm, respectively.

A set of vacuum thermocouples of one type with thin antennas, varying in length [1] from $a = 0.01$ to 3.0 cm, was employed for the measurements. A special setting of the thermocouples and a holder for them made it possible, while changing a thermoelement, to place the joint of the thermocouple quickly and exactly at the same point in the image of the source of radiation. The relative sensiti-



The wave-lengths λ generated by the mass radiators M_1, M_2, M_3 and M_4 at a constant concentration k of the mixture for each curve. M_1, M_2, M_3 and M_4 are plotted on the abscissae in logarithmical scale. Ordinates, intensity I of radiation and reception, proportional to the galvanometer deflections α, in arbitrary units

vity β of the thermocouples was determined by passing alternating current through wires leading out the thermocurrent from the joint of the thermocouple.

The set-up consisted of a pair of concave metal mirrors; in the focus of one of them was placed a radiator, in the focus of the other, a thermocouple connected with a galvanometer φ. Many curves quite close to one another were obtained for each of the radiators; they have a steady course in the region corresponding to short antennae (1st and 2nd maximums) and a less steady course in the regions of long antennae (3rd maximum). The unsteadiness in the latter case is expressed in the slight shift of the maximum in measurements made on different days. The results of the measurements are given in the figure. The wave-lengths are determined by the curve $\lambda = \vartheta(a)$ constructed on the basis of interference measurements [1]. Curve M_1 is for the mass radiator M_1; curves M_2 and M_3, for the radiators M_2 and M_3. As can be seen from the figure, both steady maximums upon passing to radiators with grains of smaller dimension shift in the direction of short waves. The 3rd, unsteady, maximum occupies approximately the same position on all curves. The number of points on the curves M_1, M_2 and M_3 is restricted by the number of thermocouples with antennas of different length we

had at our disposal. The smooth course of the curves and several general regularities in their course furnish a basis for their interpretation.

Curves M_4 for the radiator M_4 were constructed from a small number of points and therefore they should be regarded as preliminary. On these curves there is one steady maximum near $\alpha = 0.024$ cm ($\lambda = 0.08$ cm), and an unsteady one in the region of larger antenna. By analogy with curves M_1, M_2 and M_3 it is natural to assume that the steady maximum on the curves M_4 is a second maximum of these curves; the first was not detected owing to the fact that we did not have thermocouples with antennas considerably less than 0.010 cm in length.

Discussion of Results. Let us assume that the steady maxima of the curves M_1, M_2, M_3 and M_4 were formed because the antenna of the thermocouple was in resonance with the particles of the mixture. The first maximum was caused by the electrical oscillations arising during spark discharges through the vibrational mixture in individual particles of length l; the other, by the oscillations in the particles acting in pairs, like small Hertz oscillators with a length $2\,l$. Proceeding from these suppositions we may compute approximately the coefficients $m_1 = \lambda_1/l$ and $m_2 = \lambda_2/(2l + d)$ for the wave-lengths λ_1 and λ_2 corresponding to the first and second maxima of the curves, where λ_1 and λ_2 are the wave-lengths radiated by the vibrators l and $2l$, and d is the length of the spark gap between a pair of particles, equal to 0.001—0.003 cm for small Hertz oscillators ([3],[4],[5]). These computations make it possible to establish the soundness of our assumption.

The quantity $m_1 = \lambda_1/l$ refers to the case where individual particles are the oscillating systems in the vibrational mass. For electrical oscillations of individual, isolated spheres, the ratio λ/D, where D is the diameter of a sphere and λ is the length of the radiated wave, is theoretically equal to 3.62 ([6]); values of this ratio equal to 2.4—5.1 ([7–11]) were obtained experimentally for Lodge oscillators with spheres varying in diameter from several cm to several mm. In our case $m_1 = \lambda_1/l = 3.3$—3.7 for small particles (see table). This points to the generation of electrical oscillations in individual particles of the vibrational mixture; moreover, these particles, as regards the oscillatory processes taking place in them, behave like spheres ([14]).

Curves $\alpha = \varphi(\lambda)$	Length of grains (l in cm)	1st maximum		2nd maximum		3rd maximum
		λ_1 (in cm)	m_1	λ_2 (in cm)	m_2	λ_3 (in cm)
M_1	0.094	0.35	3.7	1.21	6.4	4.3—5.3
M_2	0.082	0.27	3.3	1.10	6.7	» »
M_3	0.040	0.13	3.3	0.63	7.9	» »
M_4	0.002	—	—	0.09	15—18	0.5—2.3

From the same table it is seen that the quantity m_2, which refers to the oscillations for the particles vibrating in pairs, increases with a decrease in particle size. Whence it follows that the same regularity ([4],[12],[13]) that exists for small Hertz oscillators holds for small oscillators—a pair of particles in the vibrational mixture. The quantities m_2 and $m = \lambda/L$, where L is the length of a small Hertz oscillator and λ is the length of the radiated wave, are close to one another. A similar regularity is observed with Righi oscillators also ([8]).

It is interesting to note that the smallest particles in which electrical oscillations had been stated until now, were 0.02—0.04 cm in length; this applies to the very small Nichols and Tear oscillators ([13]). In the present investigation it was discovered that electrical oscillations are generated in particles ten times smaller in length, *i. e.* 0.002—0.004 cm.

The third maximum of the curves is caused by the radiation of chains or another type of groups that have formed from the particles in the mixture between the points where the conducting sparks enter the mass. The identical position

of this maximum on the curves M_1, M_2 and M_3 is due, apparently, to the identical dimensions of the radiating area on the wheel tire; this occurred in our case with the radiators M_1, M_2 and M_3; the somewhat diverse work regime of the radiator (in the form of a liquid tire, *etc.*) on different days should result in small shifts of this maximum. Only in the case of very small particles ($l = 20\ \mu$) was the third maximum found to be shifted; this was caused by the change in the usual conditions (shortening of conducting sparks, changing in shape of tires, *etc.*) that was necessitated in the work with the radiator M_4. The relative height of the maximum on each of the curves $\alpha = \varphi(\lambda)$ depends upon the concentration k of the mixture; this follows from the curves $\alpha = \zeta(k)$, obtained by A. P. Kalugina with the aid of several thermocouples with different-sized antennas for a vibrational mixture containing particles of mean length l. It was found that a value of k_{max}, different for different thermocouples, corresponds to the maximum $\alpha_{k\,max}$ of each curve.

The assumptions made above lead to practical conclusions. The spectrum of a mass radiator is conceived as consisting of a certain background corresponding to «white» radiation, against which three of the principal «lines» of the spectrum stand out. Two stable lines in the short-wave region of the spectrum, due to the radiation of the oscillators of predominant length l and $2l$, correspond to the «characteristic» radiation of the mass radiator. The diffuseness of these lines of the spectrum is explained in the first place by different length of the sifted particles, while the small height of the maximums is accounted for by the fact that we did not have thermocouples with antennas more sharply tuned in resonance with the oscillators l and $2l$. The third line of the spectrum is characterized by the size of the generating area of the mass radiator and for a definite work regime of this generator occupies a permanent position.

Maxwell Laboratory.
M. V. Lomonossoff State University Moscow

Received
15. III. 1944.

REFERENCES

[1] A. A. Glagoleva-Arkadieva and N. A. Sokolov, C. R. Acad. Sci. URSS, XXXII, No. 8 (1941). [2] A. A. Glagoleva-Arkadieva and A. P. Kalugina, ibid., XL, No. 8 (1943). [3] П. Н. Лебедев, ЖРФХО, ч. физич., **27**, (1), 213 (1895); его же, Собр. соч., 39, 1913; Wied. Ann., **56**, 1 (1895). [4] V. K. Arkadiev, Ann. d. Phys., **58**, 105 (1919); ЖРФХО, ч. физич., **44**, 165 (1919). [5] W. Möbius. Ann. d. Phys., **62**, 293 (1920). [6] J. J. Thomson, Recent Researches in Electr. a. Magn., 370, Oxford, 1893. [7] O. Lodge, Nature, **41**, 462 (1896). [8] A. Righi, L'Ottica della oscill. elettr., Bologna, 1897. [9] J. C. Bose, Proceed. Roy. Soc., **60**, 167 (1896). [10] G. H. Hull, Phys. Rev., **5**, 271 (1897). [11] K. F. Lindman, Soc. Scient. Fenn. Comm. Phys.-Math., **7**, 13, 1 (1934). [12] В. К. Аркадьев, Электромагнитные процессы в металлах, ч. I, 156, 1936. [13] E. F. Nichols and J. D. Tear, Phys. Rev., (2), **21**, 587 (1923). [14] A. A. Glagoleva-Arkadieva, C. R. Acad. Sci. URSS, XXXII, No. 8 (1941).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

TECHNICAL PHYSICS

A NEW METHOD OF MAKING LARGE MIRROR PARABOLOIDS FOR THE INDUSTRIAL UTILIZATION OF SOLAR ENERGY

By E. MOLERO

(Communicated by M. V. Kirpichev, Member of the Academy, 11. V. 1944)

In order to obtain high temperatures with an acceptable efficiency by means of heliotechnical set-ups it is necessary to build up a high concentration of solar rays. Such a concentration may be achieved with the aid of revolving lenses (which, in the dimensions required, cannot justify itself economically) or revolving mirrors in the shape of a paraboloid of revolution. It was also found to be impossible until now to produce large paraboloids and, in general, large mirror surfaces with double curvature. On the other hand, it is economically disadvantageous to connect up in parallel a number of small paraboloid set-ups, owing to the large losses in steam lines and capital expenditures, as well as to expenditures for maintenance.

For this reason the latest attempts to build concentrating helioset-ups were made on the basis of mirrors in the shape of a parabolic cylinder, theoretically giving at the focus a concentration of the order of 90 000 kilogramm calories /m² hour (at a natural solar radiation of 600 kilogram calories/m² hour on a perpendicular surface) and in practice only about 10 000 kilogram calories/m² hour. Such a low concentration required a very complicated receiver which, together with the other shortcomings of cylindrical-parabolic set-ups, made them uneconomical.

We have proposed a new method of making mirror paraboloids of colossal dimensions (the capacity of the set-ups and their economic indices are approximately proportional to the square of the diameter), and in practice have proved the possibility of obtaining from solar rays steam of any industrial characteristics, on an industrial scale and at any time of the year.

The present paper is concerned with the theoretical basis for the new mirror technology.

The production process reduces to the following:

H e a v y - w e i g h t S e t - u p. With the aid of a parabolic mold a concrete casting (Fig. 1) is formed in the wet state, into which are glued plates of silvered window glass. The latter upon bending under weight (in the cold state) take the shape of the paraboloid (Fig. 2).

L i g h t - w e i g h t S e t - u p. We form in the same way a concrete casting *A* (Fig. 3), place on it plates of silvered window glass *B*, on top of these a layer of glue *C*, and then another layer of glass or plywood *D*. These three layers, after gluing, form under weight a piece of paraboloid mirror which may subsequently be glued to a previously prepared wooden ribbed frame, as is usually done in airplane construction.

The cylindrical bending of glass mirrors to make a heliotechnical set-up had already been accomplished by the American scientist Eneas in 1901 (1), but complexity of assembly and low concentration made it uneconomical.

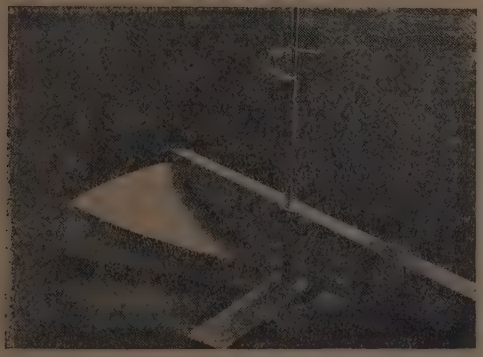


Fig. 1

The bending of glass plates into the shape of a paraboloid carried out by the author is considerably more complicated from the point of view of elasticity. Our initial experiments in 1941 may be summed up as follows:

1) With the aid of a precise parabolic mold (Fig. 1) with a focal distance of 1 m and chord of 1.5 we formed a number of concrete castings: cylindrical-parabolic, by sliding the mold along the rails of a turning lathe (a method difficult to effect for large objects), and paraboloid.

Fig. 2

Fig. 3

2) The gluing of photoplates 1.2 mm thick and 10×20 cm, 20×20 cm and 20×40 cm in dimensions on to the parabolic cylinder gave the desired results.

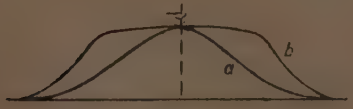


Fig. 4

Fig. 5

The illuminated bands at the focus were approximately 10 mm in width, weakening to a certain extent along the edges, which was in complete agreement with our computations made proceeding from the size of the apparent diameter of the sun and the distribution of energy along the diameter of solar disk (in Fig. 4, *a* is given a theoretical curve of the distribution of energy along the cross-

section of the focal plane). This proves that the required curve was obtained with a precision of at least up to several minutes.

However, as was to have been expected, paper placed in the focus did not burn.

3) In gluing the glass plates on to the paraboloid, the results were different. The 20×20 cm plates invariably broke. So did the 10×10 cm and 10×20 cm plates, when attempts were made to glue them under a big load. Upon decreasing the load, however, success was achieved with the same plates. A complete paraboloid made of wedge-shaped plates $12 \times 60 \times 3$ cm in dimensions was obtained rather easily.

However, an optical test gave results that did not agree with the theoretical calculations. We should have obtained a round illuminated zone of the order of 10 mm in diameter with an intensity distribution along the diameter shown in Fig. 4,*b*. Instead, bright oval spot a from 10—14×20—30 mm in dimensions was formed on individual plates (Fig. 5); around it a weakly illuminated zone *б* of the order of 10 mm in width along the entire contour. Moreover, the disproportion between the longitudinal and transverse dimensions of the bright spot was greater in the case of rectangular plates than in the case of square ones. For the paraboloid as a whole (Fig. 6) the deviation was slightly greater, but this is explained by certain defects in treatment which we will not touch upon here (attention should be paid to the distortion of the reflection in the longitudinal seams of Fig. 6, which confirms the conclusions that we make below).

Fig. 6

The thermal results were nevertheless quite satisfactory. Individual plates ignited paper; a sector of three wedge-shaped plates ignited wood and melted tin and lead; a complete paraboloid tested in Stalinabad in winter-time gave superheated steam at 470° C with the expected efficiency, and furthermore upon placing an aluminium funnel under the focus (which decreased the efficiency but increased the concentration) metals up to, and including, iron melted.

This discrepancy between the optical and thermal results is of great significance, since it proves one important fact that we later on checked during the theoretical and experimental development of a helioboiler: to obtain high concentrations the need for precision is incomparably less in the case of a paraboloid than in the case of parabolic cylinders.

4) Glass plates glued in 1943 and 1944 to a concrete casting with a radius of curvature of 9 m always gave the desired results, even in the case of 40×40 cm plates, up to 3 mm thick, bent into the shape of a sphere.

The noticeable deviation of the practical optical results from the theoretical during experiments (see paragraph 3 and Fig. 5) may be explained in only one way: the oval bright spot results from the fact that we achieved the required curvature only in one direction—along the plate where the lever is greater.

There is no doubt that the load impressed during gluing was insufficient, and while increasing it to produce a greater curvature we overstrained the glass and it broke.

The half-shaded ring around the spot is explained by the undulations of the rolled unpolished glass. In the case of a parabolic cylinder it was unnoticeable, owing to the low concentration of rays.

These suppositions required verification which we carried out as follows.

1) Verification with the aid of Maksutov's apparatus of the undulation of

the glass employed gave deviations of the order of about 30′. This explains the presence of the half-shaded ring.

2) Verifications of the curvature and elastic state of the mirror plates.

The simplified equation of the bend of the plates

$$\frac{Eh^3}{12(1-\mu^2)}\left(\frac{\partial^4 w}{\partial x^4}+2\frac{\partial^4 w}{\partial x^2\partial y^2}+\frac{\partial^4 w}{\partial y^4}\right)=q \qquad (1)$$

disregards the tangential strains arising on increasing the deflection. To determine these strains one has to resort to Karman's equations:

$$q=D\nabla^2\nabla^2 w-h\left(\frac{\partial^2 F}{\partial y^2}\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 F}{\partial x^2}\frac{\partial^2 w}{\partial y^2}-2\frac{\partial^2 F}{\partial x\,\partial y}\frac{\partial^2 w}{\partial x\,\partial y}\right) \qquad (2)$$

$$\nabla^2\nabla^2 F=E\left[\left(\frac{\partial^2 w}{\partial x\,\partial y}\right)^2-\frac{\partial^2 w}{\partial x^2}\frac{\partial^2 w}{\partial y^2}\right] \qquad (3)$$

$$T_1=\frac{\partial^2 F}{\partial y^2}h \qquad (4)$$

$$T_2=\frac{\partial^2 F}{\partial x^2}h \qquad (5)$$

$$S=\frac{\partial^2 F}{\partial x\,\partial y}h \qquad (6)$$

where q is the required load; E is the elasticity modulus; μ is the Poisson coefficient; $D=\frac{Eh^3}{12(1-\mu^2)}$; x, y are the coordinates of the plane plate; w is the deflection in the direction of the axis; h is the thickness of the plate; F is the Airy function determined by three equations (4), (5) and (6); and T_1, T_2 and S are stresses.

Prescott's method of integration [2] for the spherical bend of round plates may be employed with sufficient approximation.

We get the following formulae:

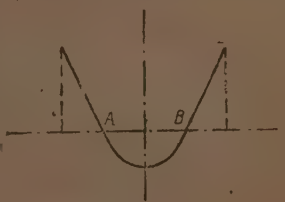


Fig. 7

$$\sigma^{\text{bend}}_{\max}=0.73\frac{Eh}{R};\quad T_{\max}=\frac{Eha^2}{16R^2};$$

$$q(r)=\frac{Eh}{4R^3}\left(r^2-\frac{a^2}{2}\right);\quad q_{\max}=\pm\frac{Eha^2}{8R^3}$$

where $2a$ is the dimension of the square plate; r is the distance from the centre of the plate; R is the radius of curvature at the focal distance $R/2$.

In Fig. 7 is given a curve $q(r)$.

In the case of a cylindrical bend $\sigma_{\max}=\frac{Eh}{2r}$.

For glass plates of different dimensions and radii of curvature these formulae give:

	$R/2$ (m)	h (mm)	$2a$ (cm)	$\sigma^{\text{bend}}_{\max}$ (kg/cm²)	$T_{\max}$ (kg/m)	$\sigma^{\text{strain}}_{\max}$ (kg/cm²)	$\sigma_{\max}$ (kg/cm²)	$q_{\max}$ (kg/m²)
Parabolic cylinder	1	1.2	1—5× any	180	—	—	—	—
Paraboloid	1	1.2	10	270	2	25	295	281
	1	1.2	20	270	12	100	370	1124
	10	1.2	20	27	0.12	1	28	1.1
	10	1.2	40	27	0.47	4	31	4.8
	10	2	20	45	0.2	1	46	2
	10	2	40	45	0.8	4	49	8

For glass $\sigma_{add} = 200$ kg/cm^2.

From this we arrive at the following conclusions which are fully corroborated by the experiments on mastering the gluing technology described above.

1. Paraboloids with a focal distance of the order of 1 m may be made only by decreasing the load; which results in a secondary curvature. This considerably increases the inaccuracy of the mirror and somewhat increases heat losses.

2. Large paraboloids may always be made even from glass of standard dimensions; moreover the glass's own weight provides a load that is already close to that required.

3. Large paraboloids may be computed by the simplified equation (1).

4. A load q is required, distributed according to the paraboloid law. However; our frame automatically gives rise to a reaction distributed according to this law if only in that part where compression is needed (A, B, Fig. 7) the load will at all points exceed the required one. This considerably facilitates production.

For the case where a convex mold is employed to construct light-weight set-ups (Fig. 3) a small load on the edges of the plates causes a bend with an error incomparably less than the permissible, as is easily seen from the simplified differential equation (1).

It is easy to prove also that the setting of the concrete does not affect the elastic state of the plates owing to their high resistance to compression, which was proved in practice on the Stalinabad set-up.

Krzhizhanovsky Power Institute.
Academy of Sciences of the USSR.

Received
11.V.1944.

REFERENCES

[1] G. D. Abbot, The Sun, N. Y., 1915. [2] Prescott, Applied Elasticity, N. Y., 1924, ch. 15.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1.

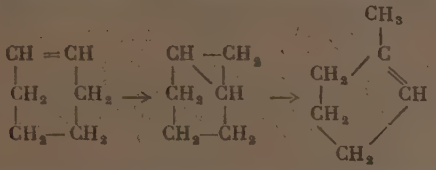
CHEMISTRY

CONTACT ISOMERIZATION OF CYCLOHEPTENE

By N. D. ZELINSKY, Member of the Academy, and J. A. ARBUSOV

We have shown recently (1) that cyclohexene when brought into contact with certain oxides (aluminium oxide, silica gel; beryllium oxide; titanium dioxide) at 350—450° was being isomerized into 1-methyl-cyclopentene-1 and that mono- and di-substituted cyclohexene homologues (1-methyl-cyclohexene-3; *p*-menthene-3) undergo a similar isomerization.

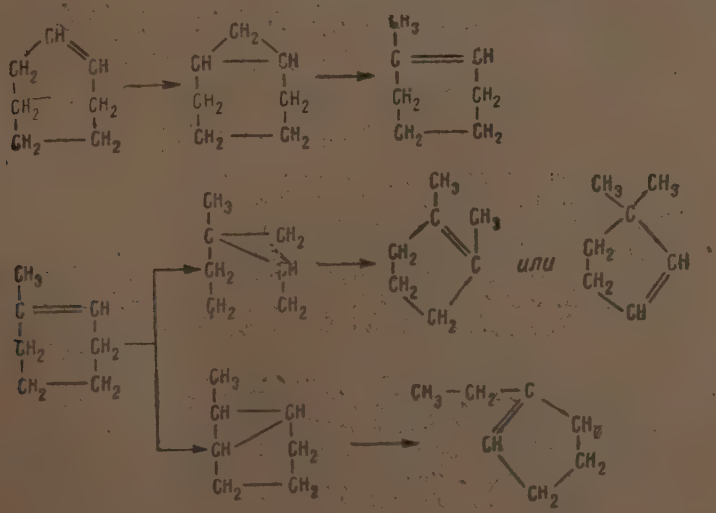
The mechanism of the isomerization of cyclohexene into 1-methyl-cyclopentene-1 under the influence of metallic oxides can be expressed through the intermediate formation of bicyclo-(0, 1; 3)-hexane according to the following scheme:



A similar scheme should be accepted as well for the isomerization of mono- and di-substituted cyclohexene homologues into cyclopentene homologues.

The behaviour of the seven-member ring when brought into contact with oxides seemed worthy of interest. In the present paper results of experiments on the isomerization of cycloheptene under the influence of silica gel are described.

It could be expected that under the action of silica gel (and of other isomerizing oxides) cycloheptene would undergo isomerization into 1-methyl-cyclohexene-1 and the latter would be further isomerized into cyclopentene homologues.



Cycloheptene was prepared by the dehydration of cycloheptanol by means of *p*-toluene-sulphonic acid and had the following properties: b. p. 112—113°/740 mm; n_D^{20} 1.4589; d_4^{20} 0.8258.

Ruzicka and Seidel (2) give for this hydrocarbon the following constants: b. p. 112—114°/720 mm; n_D^{20} 1.4585; d_4^{20} 0.8254.

Cycloheptene (35.3 g) was brought into contact with silica gel at 400° and at a rate of 5 g per hour (inner diameter of the reaction tube 15 mm; length of silica gel layer 50 cm).

The condensate (34.7 g) was separated in two parts by fractional distillation over metallic sodium:

1.	96—105°	22.9 g	n_D^{21} 1.4401
2.	105—108°	9.5 »	» 1.4461

Both fractions were united and for a second time brought into contact with silica gel under the same conditions.

The new condensate (31.7 g) yielded the following fractions:

1.	93—98°	2.0 g	n_D^{21} 1.4302
2.	98—105°	23.4 »	» 1.4383
3.	105—108°	4.8 »	» 1.4461

The main fraction 98—105° had an unsaturated character, and in order to determine its nature this fraction (21.5 g) was hydrogenated over platinized charcoal at 150°. The saturated condensate (21.3 g) had n_D^{20} 1.4180.

As in the product of hydrogenation the presence of a certain amount of methyl-cyclohexane seemed possible, the condensate was dehydrogenated over the same platinized charcoal at 300°. The dehydrogenation product (20.4 g) had a somewhat higher refractive index n_D^{20} 1.4332. This testified to the presence in the product of hydrogenation of a certain amount of methyl-cyclohexane which had been converted into toluene. In order to eliminate the latter, the condensate was treated with an equal volume of concentrated sulphuric acid (monohydrate) and the remaining hydrocarbon was washed, dried and distilled over sodium.

14.0 g of a hydrocarbon were obtained having the following properties: b. p. 92.5—97.5°/758 mm; n_D^{20} 1.4132; d_4^{20} 0.7500; found MR_D 32.64; calculated for C_7H_{14} MR_D 32.33.

The physical constants given above show that from cycloheptene we have obtained as a final result of contact transformations cyclopentane hydrocarbons C_7H_{14}, formed by the hydrogenation of cyclopentene hydrocarbons C_7H_{12} which are the direct product of the contact isomerization of cycloheptene in the presence of silica gel, proceeding through intermediate formation of 1-methyl-cyclohexene-1.

Proceeding to the structure of the cyclopentane hydrocarbons C_7H_{14} obtained from cycloheptene through stepwise contact transformations, it should be noted that, according to the scheme given above, from the theoretical point of view the formation from cycloheptene of the following three isomeric cyclopentane hydrocarbons should be expected: 1,2-dimethyl-cyclopentane, 1,1-dimethyl-cyclopentane and ethyl-cyclopentane.

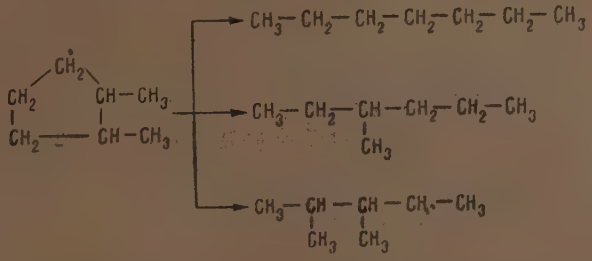
Judging by the constants, 1, 2-dimethyl-cyclopentane prevails in our product. For this hydrocarbon the following constants can be found in the literature. N. M. Kishner (3): b. p. 92.7—93°/762 mm; n_D^{20} 1.4126; d_4^{20} 0.7534. Van Rysselberge (4): b. p. 94—98°/760 mm; n_D^{20} 1.4187; d_4^{20} 0.7664. Chavanne (5): b. p. 94—99°/760 mm; n_D^{20} 1.417; d_4^{20} 0.764. Chavanne (6): cis-form, b. p. 99.25°/760 mm; n_d^{20} 1.42014; d_4^{20} 0.7718; trans-form, b. p. 91.8°/760 mm; n_d^{20} 1.40934; d_4^{20} 0.7495. Nenitzescu (7): b. p. 93—94°; n_D^{20} 1.41745; d_4^{20} 0.7613. Turova-Poljak (8): b. p. 93.8—96.8°/753 mm; n_D^{20} 1.4151; d_4^{20} 0.7577.

The mixture of cyclopentane hydrocarbons C_7H_{14} obtained by us was passed twice over platinized charcoal in a current of hydrogen at 300° and at a rate of 10 drops per minute. The condensate had the following refractive indices:

n_D^{20} 1.3899 and after distillation over metallic sodium had the following properties: b. p. 83—91°/745 mm; n_D^{20} 1.3911; d_4^{20} 0.6922; found MR_D 34.38; calculated for C_7H_{16} MR_D 34.53.

Thus, cyclopentane hydrocarbons C_7H_{14} have been converted by way of catalytic hydrogenation into a mixture of isomeric heptanes, as it should have been expected (9).

The cleavage through hydrogenation of the five-member cycle should yield from 1,2-dimethyl-cyclopentane the following hydrocarbons: *n*-heptane, 3-methyl-hexane and 2,3-dimethyl-pentane:



For these isomeric heptanes Edgar et al. (10) give the following constants: *n*-heptane, b. p. 98.4°/760 mm; n_D^{20} 1.38777; d_4^{20} 0.6836; 3-methyl-hexane, b. p. 91.8°/760 mm; n_D^{20} 1.38873; d_4^{20} 0.6870; 2,3-dimethyl-pentane, b. p. 89.7°/760 mm; n_D^{20} 1.39201; d_4^{20} 0.6952.

In the obtained mixture of isomeric heptanes the presence of prevailing amounts of hydrocarbons with an iso-structure can be stated (probably, mainly 2,3-dimethyl-pentane and 3-methyl-hexane).

N. D. Zelinsky Laboratory of Organic Chemistry.
M. V. Lomonossoff State University Moscow.

Received
3.V.1944.

REFERENCES

[1] N. D. Zelinsky and J. A. Arbusov, C. R. Acad. Sci. URSS, XXIII, 793 (1939); XXIV, 542 (1939); XXX, 712 (1941). [2] L. Ruzicka u. C. F. Seidel, Helv. Chim. Acta, **19**, 424 (1936). [3] H. M. Кижнер, ЖРФХО, **40**, 1014 (1908). [4] M. van Ryssselberge, Bull. Acad. Roy. Belgique, (5), **12**, 171 (1926); Chem. Zbl., II, 1847 (1926). [5] G. Chavanne et L. de Vogel, Bull. Soc. chem. Belgique, **37**, 141 (1928). [6] G. Chavanne, ibid., **39**, 402 (1930). [7] C. D. Nenitzescu et G. G. Vantu, Bull. Soc. chim. France, (5), **2**, 2209 (1935). [8] М. Б. Турова-Поляк и Е. В. Всеволожская, ЖОХ, **11**, 824 (1941). [9] Акад. Н. Д. Зелинский, Избранные труды, том II, стр. 176, 183, М.—Л., 1941; Н. Д. Зелинский, Б. А. Казанский и А. Ф. Платэ, ЖОХ, **4**, 168 (1934); N. D. Zelinsky and B. A. Kasansky, C. R. Acad. Sci. URSS, III, 168 (1934). [10] G. Edgar, G. Calingaert and R. E. Marker, Journ. Am. chem. Soc., **51**, 1483 (1929).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

GEOCHEMISTRY

ON THE CONCENTRATIONS OF BORON IN THE NORTH-EASTERN ORE PROVINCE

By S. S. SMIRNOV, Member of the Academy

The North-eastern province constituting a part of the huge Pacific ore belt is characterized by a number of peculiar features; distinguishing it among the other ore regions of the Soviet Union. Among these peculiarities mention should be made of the richness of many ore and other deposits of the North-eastern province in boron. In Eastern Transbaikal; «Primorie» (Okhosk sea coast) and the Okhotsk-Kolyma ore region, in the basin of the Yana, along the coast of the Chaunsky Bay and in some other areas, we see everywhere an extensive development of boron-containing minerals. In the vast majority of cases these minerals are represented by various types of tourmaline; less frequently by axinite, and quite seldom by datolite and ludwigite. Other boron-containing minerals are but of very rare occurrence.

In order to illustrate the abundance of boron in the North-eastern province suffice it to note here the Eastern Transbaikal and southern «Primorie». Tourmaline is unusually widespread in Eastern Transbaikal: either as an admixture; or as an essential component it has been found in a great many mineral deposits — from pegmatites to mesothermal lead-zinc deposits. Perhaps only the epithermal deposits are free from a tourmaline admixture.

Because of the abundance of this mineral in some groups of deposits of Eastern Transbaikal it has been found advisable to separate a special tourmaline-quartz gold-ore formation; tourmaline quartz molybdenum deposits; tourmaline-lead-zinc deposits; *etc.* The tourmaline-quartz «rocks» which are extensively developed and lacking any useful components are also separated. It is in these rocks that the bulk of the boron of Eastern Transbaikal is contained.

In the southern part of the «Primorie» large boron accumulations have been discovered in the Olguino-Tetyukhe ore region. Here, unlike Eastern Transbaikal; tourmaline is scarce, but axinite and datolite are widely distributed instead. Axinite; in particular; is the chief mineral of the magnetite-bearing skarns of the Gorbushin deposit. There is a large amount of axinite and datolite in the gangue of the Verkhny mine. But particularly great are the quantities of these two minerals in the mineralized limestones of the so-called Khrustalny offset of the Tetyukhe group of deposits. Within an area of 2—3 km the Triassic limestones of Khrustalny offset are replaced to some extent, sometimes completely, by axinite; datolite, grossularite, mangan-hedenbergite; quartz. Over some considerable areas the amount of datolite is so great that naturally the idea suggests itself as to the possible commercial utilization of the datolitized limestones of Khrustalny offset. As to the total amount of boron; this deposit may undoubtedly be considered as the largest of all those known to-day in the Soviet Union.

In the northern regions of the North-eastern province (the Yana, Okhotsk-Kolyma; Chaun and others) the large concentrations of boron known at present are represented chiefly by the quartz-tourmaline deposits often carrying considerable amounts of tin. In the same regions at several points considerable accumulations of ludwigite and axinite have also been encountered.

These illustrations will suffice to show how rich in boron the province under consideration is. The following points should be stressed, however.

The study of the Mesozoic and Cenozoic metallogenesis of the north-east

makes us assume that the stages of mineralization of different age are more or less similar from the geochemical standpoint. And if, say, the ore deposits of East Transbaikal, most of which are Upper Jurassic in age, be compared with the Lower Tertiary (Upper Cretaceous?) deposits of the Primorie, no essential difference in their composition will be noted. A sharp distinction is manifested only in the facies of mineralization. In Eastern Transbaikal facies of moderate depths are encountered, while in the southern part of the Primorie it is facies of shallow depths and in some cases almost near-surface formations. It is noteworthy that the lead-zinc ores of Tetyukhe, with their skarn-like gangue, have an extremely peculiar structure. Coarsely collomorph textures, abundant primary voids, sometimes reaching several tens of cubic meters, the development of zeolites (occasionally very considerable) in association with silicates; all these peculiarities and many others furnish convincing evidence of the formation of deposits at shallow depths. It is characteristic that the above-described boron deposit of the Khrustalny offset, except for the coarse-grained nature of its ores, closely resembles the datolite deposits associated with the Pyatigorsk laccoliths of trachyliparites. Distinct features characterizing deposits formed at shallow depths are shown also by the tin deposits of the Primorie, very close to those of Bolivia.

The hypothesis of the geochemical relationship between the different stages of the Mesozoic-Cenozoic metallogenesis of the North-eastern province, the hypothesis of a certain organic integrity of the whole young cycle of mineralization, certainly requires further proofs. Without entering for the moment into a discussion of the subject, it should only be pointed out here that the nature of development of boron concentration is not in conflict with the hypothesis advanced.

Using the latter as a starting point, one may assume that boron is also characteristic for the youngest stages of the Cenozoic volcanism of the north-east. On Kamchatka we know some cases of boron occurrence in connexion with the recent volcanic activity. The same is evidenced by the huge deposits of borates in the American section of the Pacific ore ring.

After all that has been said above the investigation of the extreme eastern parts of the North-eastern province for the presence of boron appears necessary. The youngest stages of mineralization are most distinctly pronounced here, and we may expect the presence of borate deposits, both primary and redeposited, which are of greatest interest from the economic standpoint. Along with this, it is expedient to advance the problem as to the economic evaluation of the large datolite deposit of the Khrustalny offset in the Tetyukhe region.

In conclusion a few words must be said about the rare forms of boron occurrence in the North-eastern province. In addition to ludwigite met with at several points and in considerable concentrations; only danburite (in the wolframite-quartz deposits of Transbaikal) and an extremely rare mineral—yeremeyevite have been as yet encountered. One cannot help saying that in view of the abundance of boron that characterizes the North-eastern province, a much larger list of boron minerals might be expected.

These problems seem to have simply been overlooked by the investigators. And it is the more regrettable, as a study of the nature and extent of boron occurrences; boron being the most characteristic element of the North-eastern province; would shed light upon many problems of the metallogeny of this region.

It should be borne in mind, too, that some minerals of boron; tourmaline in the first place, are so specific for many ore deposits of the province that we may consider them as a valuable guide-feature in search work. The value of this feature is still enhanced by the fact that tourmaline may frequently be developed not only within strictly localized ore bodies, but also in the rocks enclosing these bodies. Considerable tourmalinization halves are formed which are easily found in the case of a more or less thorough search; even if the deposits are poorly exposed, as it is usually the case in the North-eastern regions.

Received
8.IV.1944.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

CHEMICAL TECHNOLOGY

DESULPHURIZATION OF BENZINES ON A NICKEL CATALYST

By G. N. MASLIANSKY

(Communicated by A. N. Nesmeyanov, Member of the Academy, 10.III.1944)

It is generally known that nickel catalysts are very sensitive to poisoning by sulphur and sulphur compounds. Yet, this notwithstanding, several authors have attempted to bring about a desulphurization of benzines upon nickel catalysts by employing the method of catalytic hydrogenation.

Thus, Furt and Enike (1), Brown (2), Titz (3), Titz, Shuikin and Epifansky (4) have made attempts to desulphurize benzines of different origin (from petroleum, shales, brown coal, *etc.*) over a nickel catalyst at 300—400 °C in the presence of hydrogen. At the early period of the work of the catalyst a deep desulphurization of benzines was observed. But later on the activity of the catalyst decreased rapidly, owing probably to chemical binding between nickel and the sulphur contained in the benzine.

Elgin, Wilder and Taylor (5), Elgin (6) and Taylor (7) have found that when sulphur-containing benzines are passed over a nickel catalyst at 300—400°C at atmospheric pressure, the content of sulphur in the successive samples of the purified benzine at first increases rapidly, but afterwards comes to a constant value. Further on the activity of the catalyst remains stable and all the time a continuous evaluation of hydrogen sulphide is taking place. In this way the sulphuric compounds undergo a transformation attended by the formation of hydrogen sulphide which moves out of the catalytic zone. If hydrogen and benzine vapours were passed together over the same catalyst, the depth of sulphurization showed a slight increase. Nevertheless, in all experiments the degree of desulphurization after the catalyst had reached a constant level of activity was found to be insufficient; the content of sulphur in the benzine had never decreased more than 2—3 times.

In the above-cited works the purification of sulphuric benzine by the hydrogenation of nickel catalyst was conducted at much higher temperatures than those at which the hydrogenation of unsaturated and aromatic hydrocarbons is usually carried out over this catalyst (100—200° C). In spite of this no deep desulphurization of benzine was attained; though the work of the nickel catalyst had been stable for a long time.

The present author attacked this problem by making use of the protective action of hydrogen. By some earlier work carried out at the High-pressure Institute (8,9) it had been proved that increase of hydrogen pressure props up the activity of a hydrogenizing catalyst. Moreover, with regard to a nickel catalyst Taylor (7) had put forward the assumption, based on the reversibility of the reaction $NiS + H_2 \rightleftarrows Ni + H_2S$, that if the process was carried out under a higher pressure of hydrogen, the free surface of the nickel catalyst should hold on far a longer period, because under these conditions metallic nickel is not easily transformed into sulphide.

In the present work the experiments were run with a nickel catalyst put upon kieselgur. In each of the tests a fresh portion of the catalyst was applied and its reduction took place under standard conditions (volume velocity of hydrogen, 500; temperature conditions: 300° C for 2 hours; 350° for 2 hours; 380° C for

12 hours, and 425° C for 8 hours). The content of nickel in the reduced catalyst was about 50 per cent. Subjected to the hydrogenation were straight distillation sulphuric benzines with a boiling end temperature of 110—115° C. The experiments were conducted under hydrogen pressure in a set-up that was described earlier ([10]). The content of sulphur in the initial and purified samples of benzine was determined by the lamp method.

To begin with, the experiments were run under equal conditions on benzines of different sulphur content which ranged from 0.12 to 0.29 per cent. The temperature was 200° C; pressure, 10 atm; the supply of benzine, 2 volumes per one volume of catalyst per hour, the relative volume concentration of hydrogen and benzine being 6 : 1.

Table 1

Desulphurization of Benzines of Different Sulphur Content over Nickel Catalyst

Conditions: temperature, 200° C; pressure, 10 atm; M_{H_2}: $M_b = 6 : 1$; supply, 2 volumes of benzine per volume of catalyst per hour. Amount of catalyst, 25 cm³

Nos. of tests	S, % in initial benzine	Hours elapsed since the start of the experiment (S, %)									
		10	15	20	30	40	50	60	70	80	90
6	0.29	0.015	0.025	0.035	0.055	0.080	—	—	—	—	—
17	0.20	0.010	0.010	0.015	0.020	0.020	0.025	0.025	0.030	0.040	0.040
12	0.12	—	—	—	0.01	0.01	0.01	0.01	0.01	0.01	0.01

As may be seen from Table 1, the poisoning of the catalyst was proceeding rapidly when the initial content of sulphur in benzine had been 0.29 per cent; the successive samples of the purified benzine showed a rapide increase in sulphur. With a 0.2 per cent content of sulphur the poisoning of the catalyst was making a slow progress. And finally, with 0.12 per cent of sulphur in the initial benzine the catalyst showed a perfect stability reducing the content of sulphur as much as 10 times.

Since the partial pressure of hydrogen in the above experiments was equal, the preliminary conclusion to be drawn is that the dilution of a sulphur compound vapour by hydrogen tends to keep a nickel catalyst active.

To check this conclusion experiments 17 and 18 with a benzine containing 0.2 per cent S were started. The only difference between the conditions under which they were carried out is that the ratio M_{H_2}: M_b was 6 : 1 in experiment 17, while it was 9 : 1 in experiment 18 (which means, of course, that in the latter case the benzine vapour was more strongly diluted with hydrogen). The answer furnished by these experiments is in the affirmative, as is obvious from the data of Table 2. In fact, in the experiment 17 the nickel catalyst was being poisoned at a slow rate, whereas the increase of the M_{H_2}: M_b ratio from 6 : 1 to 9 : 1 (experiment 18) stabilized the work of the catalyst.

Table 2

Effect of Relative Concentrations of Hydrogen and Benzine upon the Stability of the Catalyst on Desulphurization

Conditions as referred to in Table 1: initial content of sulphur 0.2%

Nos. of tests	$M_{H_2} : M_b$	Hours elapsed since the start of the experiment (S, %)									
		10	20	30	40	50	60	70	80	90	100
17	6 : 1	0.01	0.015	0.020	0.020	0.025	0.025	0.030	0.040	0.040	—
18	9 : 1	0.01	0.01	0.015	0.015	0.020	0.020	0.020	0.020	0.020	0.020

In order to prove that straight distillation sulphur-bearing benzines can indeed be freed from their sulphur by a low-temperature hydrogenation over a nickel catalyst, the latter was subjected to a prolonged test.

Two benzine samples containing 0.12 and 0.15 per cent of S, respectively, were subjected to desulphurization. The conditions of the experiment were as follows: pressure, 10 atm; rate of supply, 1.7 volumes of benzine per 1 volume of catalyst per hour; $M_{H_2}:M_s = 6:1$; temperature, not above 200°C. The catalyst was tested continuously for about 27 days on end. The evolution of hydrogen sulphide set in after the catalyst had been working for 20 hours.

Table 3

Long-Term Test of Nickel Catalyst on Desulphurization of Straight Distillation Benzines

Hours elapsed since the start of the exper.	Temperature of the process, °C	S, % in purified benzine	Hours elapsed from the start of the exper.	Temperature of the process, °C	S, % in purified benzine
Sample No. 1 with 0.12% S			Sample No. 2 with 0.15% S		
4	130	0.005	250—276	200	0.017
14	»	0.012	284—304	»	0.012
20*	»	—	308—326	»	0.017
26	»	0.015	336—350	»	0.017
30	»	0.015	358—386	»	0.019
48— 60	160	0.007	392—402	»	0.019
68— 84	»	0.009	418—442	»	0.020
90	»	0.020	450—476	»	0.015
128—154	200	0.011	484—502	»	0.017
158—170	»	0.012	510—536	»	0.017
			548—564	»	0.018
			572—604	»	0.019
Sample No. 2 with 0.15% S			606—626	»	0.018
			638	»	0.018
176—188	200	0.014			
194—228	»	0.015			
Sample No. 1 with 0.12% S					
236—242	200	0.010			

Note. Hydrogen sulphide appeared in the evolving gas.

As is seen from Table 3, the activity of the catalyst had diminished but slightly after 638 hours of work. And the benzine samples showed a decrease in sulphur by as much as 8 to 10 times.

Over 25 cm³ of catalyst containing about 12 g of metallic nickel there had passed 27.1 litres (18.4 kg) of benzine. The amount of sulphur removed in this way was more than 3.5 times the amount necessary for complete chemical binding of the nickel. It will be obvious that the nickel catalyst had worked as a sulphur-stable contact, and that the benzines had let loose their sulphur through the decomposition and hydrogenation of sulphur compounds, whereby sulphur separated in the form of hydrogen sulphide.

Central Institute
of Aviation Fuels and Oils,

Received
2.III.1944.

REFERENCES

[1] А. С. Броун и А. П. Сиверцев, Химия сернистых соединений. Л., 193 стр. 174. [2] А. С. Броун, Хим. тв. топлива, 5, 267 (1934). [3] И. Н. Тиц, Ученые записки МГУ, III, 165 (1934). [4] И. Н. Тиц, Н. И. Шуйкин и П. Ф. Епифанский, Нефтяное хозяйство, № 5, 52 (1935). [5] J. C. Elgin, G. H. Wilder and H. S. Taylor, Ind. Eng. Chem., 22, 1284 (1930). [6] J. C. Elgin, ibid., 22, 1290 (1930) [7] H. S. Taylor, Oil and Gas Journ., 29, No. 27, 38 (1930). [8] G. N. Maslianshy and M. S. Nemtzov, C. R. Acad. Sci. URSS, II, 407 (1935). [9] М. С. Немцов, Успехи химии, 7, 1641 (1938). [10] Г. Н. Маслянский, ЖОХ, 13, 541 (1943).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

CYTOLOGY

A CONTRIBUTION TO THE ACETO-CARMINE TECHNIQUE

By G. G. TINIAKOV and A. P. TINIAKOVA

(Communicated by L. A. Orbeli, Member of the Academy, 29.III.1944)

The aceto-carmine method has received an important place in cytogenetics within the recent years.

We find it useful to describe some new results obtained by us while working according to this method.

The great advantage of the aceto-carmine method consists in that it permits of making within a short time a large number of slides, quite satisfactory for refined cytological studies. However, alongside of this advantage the aceto-carmine method has the disadvantage of the slides prepared according to it being but poorly stable.

In this connexion attempts have more than once been made to develop a method of making temporary aceto-carmine slides permanent.

Among the several methods of making permanent aceto-carmine slides the best available at present and the most universal one is that of Bridges (²). It gives equally good results both with vegetable and animal tissues, which has been checked up by us on practice. Bridges applied it for making slides of salivary gland chromosomes.

The larvae which were to serve as material for the slides were brought up at low temperature on a food rich in yeast. When ready for pupation, they were kept for some time on ice. After this their salivary glands were taken out in cold Ringer solution or 0.73 per cent saline solution and were transferred to ordinary carmine (without iron).

The carmine should also be cooled, or placed on ice.

In this aceto-carmine solution the salivary glands are stained from 20 minutes up to several hours. The slides made in this way are further on subjected to the following treatment (the latter is equally applicable to slides prepared by Bridge's method under application of cold; and to those made in the ordinary way).

It consists in that the slides are subjected to the action of alcohol vapour. For this purpose a large vessel is required. We recommend a round exsiccator with a ground cover. 96° alcohol is poured over the bottom of this vessel, and its walls are lined with filtering paper. The slides are placed somewhat obliquely on its projection. A wire ring with compartments for the slides may be put in the exsiccator; the slides will then stand vertically and a larger number of them can be put in. After the exsicattor is loaded, it is covered with the cover; the edges of the latter being prealably smeared with vaseline. The slides should be kept in alcohol vapour over night, for 24 hours and more. Here the slides become dehydrated.

Part of the slides drop their cover-slips while in the exsiccator; the majority of them; however, keep their slips on. The slides should therefore be transferred from the vapour camera to 95—96° alcohol; where they remain until the cover-slips become detached. In case they fail to drop even in alcohol; such slides should be placed in a Petri dish with some 96° alcohol; and the slips should

be slightly lifted at the one corner by means of a scalpel; while from the opposite side the slip should be held up with a forceps. The cover-glass is then readily lifted.

The procedure of removing the cover-slips with the aid of a scalpel may be recommended in all cases where the slides have just been taken out of the vapour camera: the cover-slips are easily removed from all of them without any additional alcohol treatment. After the removal of the cover-slips; part of the material usually remains on the slide and another on the cover-slip. It is much more convenient when the whole of the material remains on the object-glass. In order to attain this in all cases, Bauer (1) recommends a pretreatment of the slides, consisting in covering them before using with a thin layer of egg albumen, in the same way as it is usually done in preparing microtome slides. After this, the albumen is left to dry. The opposite surface of the cover-slip should be covered with an extremely thin layer of fat.

In slides prepared under application of such glasses; the chromosomes would usually adhere only to the object-glass.

It should be noted that the treatment with alcohol vapour is highly beneficial both for vegetable and animal tissues. The chromosomes are scarcely affected by this treatment and fully preserve their bright colour and contrasts; which are usually seen in freshly made aceto-carmine preparations.

One of the drawbacks of the aceto-carmine method is the red coloration assumed by the chromosomes, which is unpleasant and tiresome for the eye under bright illumination of the microscope. Besides; for photomicrographs such a coloration is also inconvenient; since it requires special light-filters. In this connexion we tried to produce additional staining of the aceto-car ine preparations in the ordinary Heidenhain haematoxyline. With this aim in view the slides are quickly runned from the vapour camera into water. After water they are placed for one-two minutes into a 2 per cent solution of iron alumen as a mordant.

Next, after having dipped the slide 3—4 times into distilled water; itis immersed 2—3 times into a strong, ripe haematoxyline after Heidenhain. From the hâematoxyline the slide is transferred to a vial with water; is rinsed and the intensity of the stain is checked up under low power. If the slide is found to be understained, it is dipped once or twice more into haematoxyline. If it is overstained, it is treated with iron alumen. If the staining is satisfactory, the slide is runned through alcohol to xylol and mounted in balsam. The whole procedure of additional staining, including mounting in balsam; takes no more than 10—15 minutes. Additional staining yields in many cases good results. From red the salivary gland chromosomes of the various *Drosophila* species turn into dark-brown or even nearly black. The contrasts are in many cases strongly augmented.

Such chromosomes are readily microphotographed without application of special light-filters.

Remarkable results after additional staining yield also vegetable objects: barley, wheat, onions, crepis, and so on. Upon restaining the plant chromosomes become black. An identical restaining of the aceto-carmine preparations of animal objects yields equally good results.

For example, we successfully restained the chromosome complement of the embryonic kidney of the pig.

It should; however, be noted that restaining with Heidenhain's haematoxyline of poor slides does not improve them, good results being attained by restaining only in preparations which had been successfully stained with aceto-carmine. Additional staining with haematoxyline will improve only such preparations as were for some reason understained with aceto-carmine. Thus, we have obtained a slide of diakinesis in 42-chromosome wheat. The chromosomes were understained, but the background of the cytoplasm was light. Restaining with haematoxyline yielded perfect results. Diad chromosomes became black and conspicuous (Fig. 1).

The application of this method to the restaining of the meiotic chromosomes is also quite possible.

Our attempt to restain aceto-carmine preparations was not limited to the application of Heidenhain's haematoxyline. We have also tested Carazzi's haematoxyline which occasionally gives a lighter colouring, it is true, lut a delicate restaining of the salivary gland chromosomes. Moreover, we successfully applied the impregnation method of aceto-carmine preparations.

This method has as yet been tested only on vegetable objects fixed in Carnoy mixture.

Among the heavy metals osmium has been applied. The cover-slips were removed from good slides with the aid of alcohol vapour. For impregnation a rec-

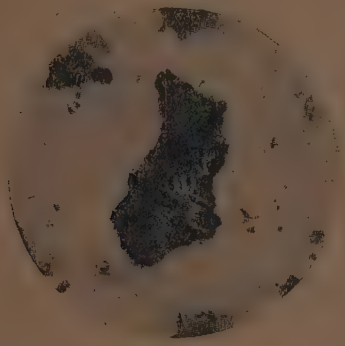


Fig. 1. Photomicrograph of late diakinesis in 42-chromosome wheat from an aceto-carmine preparation restained with Heidenhain's haematoxyline

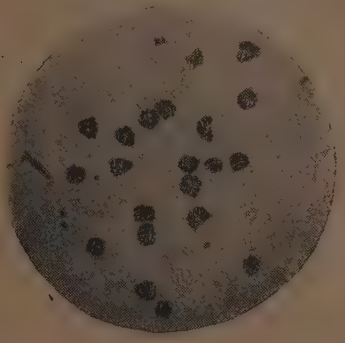


Fig. 2. Microphotograph of somatic chromosomes of barley from an aceto-carmine preparation subjected to impregnation with osmium

tangular glass vessel was used, somewhat wider than the object-glass; into it we insert a wooden stand with compartments for glasses, pour in a 1 per cent solution of osmic acid; and put in the slides. The vessel is covered from above with a glass plate slightly smeared with vaseline, to ensure better tigthness. The vessel loaded in this way is placed into a thermostat at a constant temperature of 38° C for 5—7 days. After this period, the slides are removed, rinsed in distilled water and checked under the microscope. After a stay in osmic vapour the slides become deeply blackened, since osmium is profusely deposited in various tissues and in all parts of many cells; excluding the chromosomes.

In the case of a successful experiment the following pictures are seen in the cells containing visible chromosomes: the plasm is deep black throughout, no light being transmitted, while all the chromosomes contained in it are quite colourless, since they do not absorb the heavy metal. A distinct picture rich in contrasts, and quite unusual to the kariologist is obtained: the real chromosomes are seen as on a negative (Fig. 2). As may be seen in the figure, osmium is deposited around the chromosome body with such a precision and strictly tracing its outline that the most minute details of its morphology are excellently brought out. All the constrictions, satellites, twists, individual chromatids *etc.* are figured out with remarkable distinctness and accuracy. Moreover, a precise analysis under high power shows that in case the salts are being deposited on the chromosomes, though in minimum quantities, this takes place at exactly definite loci, which serves to bring out in prophatic chromosomes their fine chromomere structure. Preliminary results obtained on a limited material as yet point out that differential deposition of osmium salts takes place along the salivary chromosomes, too.

But before placing salivary gland chromosomes into osmium, preliminary fixation with other fixatives is necessary.

It should be noted that the differential chromosome analysis by means of impregnation according to this method is rather capricious and does not always succeed.

To secure successful results, impregnation should be done on a vast material, by placing into osmium from 10 to 20 preparations at once; by all means successful preparations may occur among them.

The chief advantages of the aceto-carmine method are the quickness of making slides; the possibility of treating vast material, and the spreading of the cell material nearly in a plane. All these advantages of the method may be successfully made use of, say, in the studies of malignant tumours.

Some preliminary experiments in this direction have already been conducted by us on Ehrlich's cancer of white mice.

Institute of Cytology, Histology and Embryology.
Academy of Sciences of the USSR.

Received
29.III.1944.

REFERENCES

[1] H. Bauer, Proc. Nat. Acad. Sci., 22 (1936). [2] C. B. Bridges, Drosophil. Information Service Methods, Issue 6, XI (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

GENETICS

TRANSLOCATION PROCESS IN INERT AND ACTIVE REGIONS OF CHROMOSOMES IN *DROSOPHILA MELANOGASTER*

By B. A. KIRSSANOW

(Communicated by L. A. Orbeli, Member of the Academy, 11.II. 1944)

The purpose of the present work was to determine the frequency of X-ray induced translocations between the inert regions of the II and III chromosomes and to compare the value obtained with: 1) the frequency of translocations between the active regions and 2) with that of translocations between the active and the inert regions. As to the latter two cases, corresponding frequency determinations are available in literature.

For the comparison we undertook use was made both of literary data and of data obtained by ourselves.

The frequency of translocations between the inert regions has been determined by us with the aid of a line heterozygous for a translocation which we denoted by No. 50.

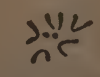


Fig. 1. Oogonial metaphase plate of individual heterozygous for translocation No. 50

This is a translocation between the II and the III chromosomes (II is carrying the inversion Curly—Cy; III, the gene Dichaete—D); the translocation breaks are located in the inert regions of the chromosome.

The localization of the breaks has been determined from the examination of slides made of salivary glands of the larvae; the chromosomes of the salivary glands of such larvae as are heterozygous for the translocation No.50 show no translocational changes whatever. The localization of breaks in the inert regions is evidenced by the arrangement of the V-shaped II and III chromosomes in the metaphase: in the oogonia bearing the translocation No. 50 in the heterozygous condition the chromosomes show a cross-like arrangement (Fig. 1).

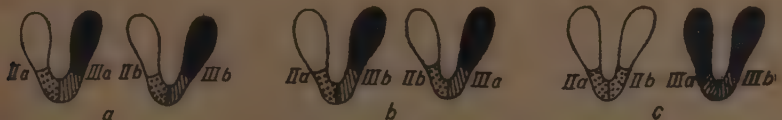


Fig. 2. Scheme of formation of various types of repeated translocations: *a*, initial translocation; *b*, repeated translocation which does not disturb the genetic linkage of the II and III chromosomes; *c*, repeated translocation resulting in the formation of freely distributed II and III chromosomes

Crossing-over data go also to confirm the localization of the breaks in inert regions (in the III chromosome the crossing-over is normal).

The rate of translocations between the inert regions of the II and III chromosomes is determined by us in the F_2 of the cross:

$$P\ \delta\ \text{X-rayed}\ \frac{\text{Cy D tr No.50}}{+} \times \text{♀ wild}$$

$$F_1\ \delta\ \frac{\text{Cy D tr No. 50}}{+} \times \text{♀ wild}$$

Among the recent generation F_2 the progeny of an individual heterozygous for the translocation comprises only two classes of individuals: Cy D and normals, while the Cy and D flies do not survive, since hyper and hypoploid combinations yield non-viable zygotes. If, as seen from Fig. 2, a translocation arises in which the two breaks have taken place in inert regions, then the translocation will result in a free distribution of the II and III chromosomes, without the production of non-viable combinations: in separate exceptional cultures additional Cy and D classes make appearance in the F_2.

Our experiments revealed no more than 50 per cent of translocations between the inert regions of the II and III chromosomes (Fig. 2)*. It should be pointed out, however, that similar results may be due to translocations accompanied by breaks in the active regions, directly adjoining the inert regions.

The more remote the point of the break in the active portion of the chromosome from the inert region, the less is the number of flies constituting one of the additional classes of the exceptional cultures. In case the break in the active region is sufficiently remote from the inert region, the translocations formed anew will not become manifest **.

The cultures containing the additional classes Cy and D were reproduced by crossing

$$\delta\ \frac{\text{Cy D tr No.50}}{+} \times \text{♀ wild}$$

The salivary glands of the larvae heterozygous for these translocations were examined in order accurately to locate the break: whether it takes place in an inert portion of the chromosome or in a close proximity to it, being separated from the inert region by a small portion of active substance only.

The F_2 under experiment included 0.62 per cent of the exceptional cultures with additional Cy and D classes (this figure does not comprise one case which seemed questionable).

In agreement with what has been said above, in order to obtain the actual translocation frequency we redouble the figure 0.62, and obtain: 1.24 ± 0.24 per cent.

The data obtained in the F_2 from X-raying of males $\frac{\text{Cy D tr No.50}}{+}$ are given in the table, a.

From the frequency at which the translocation arises in the male whose structure is normal with respect to translocation (table, b) we have computed the magnitude which in the subsequent will be termed the «expected». This magnitude has been computed on the assumption that the II—III translocations take place at an equal frequency in the three following combinations: active region to active region, active region to inert region, and inert region to inert region.

As may be seen from the literary evidence ([2], [3]), the inert region of the II and III chromosomes occupies at the moment of the formation of translocation somewhat less than $^1/_5$ of the chromosome's length. Hence it is evident that the number of breaks in the inert portion of one chromosome coinciding with the breaks in the inert portion of another chromosome makes up $^1/_{25}$ of the total number of translocations in the II—III chromosomes.

Making use of our material we have calculated $^1/_5$ (in per cent) of the translocation frequency in II and III chromosomes, and by multiplying the probabilities have derived the «expected» magnitude: 0.40 per cent. Consequently, the experimental value given above (1.24 ± 0.24 per cent) exceeds the expected one.

* Throughout the note we speak of the inert regions of the II and III chromosomes, adjoining the locus of fixation of the thread of the spindle.

** On the possibility of appearance of dicentric and acentric chromosomes see our note([1])

a) Frequency of Secondary Translocations within Translocation No. 50*

		Y-II-III	Cultures with Cy	Cultures with D	Cultures with Cy and D	Total number of cultures
Upon X-raying	Number of F_2 cultures	200	6	28	28	4347
	%	4.60	0.14	0.64	0.64	—
No X-raying	Number of F_2 cultures	—	—	—	—	1440
	%	—	—	—	—	—

b) Frequency of Primary Translocations

		II—III	Y—II	Y—III	Y-II-III	Total number of cultures
Upon X-raying	Number of F_2 cultures	246	47	57	24	2743
	%	8.97	1.71	2.08	0.87	—

* The columns entitled «Cultures with Cy» and «Cultures with D» comprise such translocations in which there is at least one break within the active substance. Column «Cultures with Cy and D» encloses such cases where translocations between the inert regions of the II and III chromosomes take place. One of the cases recorded under this heading and inclosed in the figure 0.64 is questionable as to the point of the break. This case is omitted from our subsequent calculations of the rate of translocations between the inert regions.

The difference (0.84 ± 0.24) between these magnitudes is significant. This difference is even somewhat smaller than the one actually observed, since when computing the expected value, $^1/_5$ has been calculated from the total number of translocations, inclusive of the translocations which involve the inert regions, as well.

The difference between the frequency of translocations in the active regions and that of translocations in the inert ones will therefore also somewhat exceed 0.84.

An analysis of frequency of translocations between the II and III chromosomes and the Y chromosomes has shown that the inert substance of the latter yields translocational re-arrangements with the active substance at the same rate as the active substance with the active one.

The whole of the inert substance of the Y chromosome, or at least its greatest portion, shows no increase in the frequency of translocations with the inert regions of the II and III chromosomes (as compared with the translocations involving the Y chromosomes and the active substance of the II and III chromosomes). The same relations seem to hold good for the inert regions of these chromosomes, one the one hand, and the inert region of the X chromosome, on the other.

The difference between the sex chromosomes and the autosomes may possibly be due to the homology between a part of the inert regions of the II and III chromosomes; and the lack or very slight degree of homology between the inert regions of the sex chromosomes, on the one hand, and the autosomes, on the other,

On the basis of the results obtained from our experiments and the data available in literature we discern a number of causes which have been supposed to account for the possible increase in the frequency of translocations arising between the inert regions of the II and III chromosomes (dominant lethals producing the elimination of a part of the translocations in active regions, the lability of inert regions with respect to external action). After having discarded these causes, the most probable cause which seems to account for this increase is an interaction, similar to a conjugation, between the two regions, taking place in the haplo-stage (spermatide or the sperm). Hence it should be concluded that the genes, if accounting for conjugation at all; preserve this function during the haplo-stage, as well. Data obtained in the course of this work went also to confirm the results of our preceding investigation [1], *viz.* that the combining of chromosome fragments in the process of translocation is no casual one.

Received
11.II.1944.

REFERENCES

[2] Б. А. Кирсанов, Биологич. журн., VI, № 4 (1937). [2] E. Heitz, ZS. Zellforsch. u. mikr. Anatomie, **20**, H. 1 (1938). [3] H. Bauer, M. Demerec and B. P. Kaufmann, Genetics, **23**, No. 6 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

PLANT PHYSIOLOGY

MODIFIED ANATOMICAL STRUCTURE IN KOK-SAGHYZ ROOTS AND ITS BIOLOGICAL IMPORT

By S. W. BULGAKOV

(Communicated by A. A. Richter, Member of the Academy, 6.II.1944)

The slight thickening of roots observed in ordinary, unimproved populations of kok-saghyz is due to their anatomical structure; a typical feature of the latter is the presence in the centre of the root of a single narrow cambium cylinder investing the thin compact pith cylinder. Naturally enough, the insignificant dimensions of the cambial tissue cannot possibly ensure a rapid growth of the bark and of the laticiferous vessels it contains. As a result of the breeding work carried out during the recent years it has been found possible, however, considerably to increase the thickness of the roots of kok-saghyz without reducing their rubber content, which is particularly important. Among ordinary kok-saghyz populations and if the individual plants are standing wide apart, one may occasionally encounter roots whose thickness amounts to some 15—25 mm at the crown. Among our breeding material the best plants showed the following figures: 37 mm in 1940; 43 mm in 1942 (ordinary agricultural conditions) and 52 mm (improved agricultural conditions); in 1943 we obtained among plants transplanted from seed-beds such whose root diameter attained 70—90 mm.

According as the root increases in thickness, its weight augments as well. In the case where a plot is set with plants standing wide apart, non-branching taproots of the best plants may attain a weight of 80—90 g; strongly branching ones, up to 160—200 g. When the seedling method was applied and the seedlings were preliminarily grown in a greenhouse, we obtained in 1943 roots whose weight attained 250 g. As a result of repeated selection the average raw weight of the roots in the best families reached 40—50 g, while in ordinary populations it is found to fluctuate between 10 and 18 g.

The rubber content in the breeding families makes up 9—10 per cent to dry weight; this should be taken to mean that in spite of the considerable increase in the size of the root their content of rubber is by no means reduced, but even somewhat increased as compared to that in the ordinary plants of thin-rooted populations.

The abrupt and rapid increase in the size of the kok-saghyz root, accompanied with no reduction in rubber content, is no casual phenomenon. When brought up under definite conditions and subjected to systematical selection, certain kok-saghyz forms developed new biological properties connected with a modified anatomical structure of their roots.

In 1939 we received from the collective farm «Chervona Smena» (Minsk province of the White Russian SSR) a very big kok-saghyz root; it weighed 160 g and the thickness of its crown was 42 mm. The examination of the root-tip in cross-sections revealed an unusual structure of this root: instead of a single central vascular cylinder it contained several vascular cylinders scattered in the

root parenchyme. In its lower part the root showed an ordinary structure, having one central vascular cylinder.

The picture observed prompted us to investigate the anatomical structure of the thick roots obtained by way of selection. It has soon been found that any large root showing a thick crown with a typical ribbed spiral structure, has a modified anatomy. The vascular bundles scattered throughout the parenchyme, sometimes ten and more in number, are surrounded by a cambium of their own and each of them has a particular system of laticiferous vessels (1).

In the same year (1939) it was discovered that occasionally such plants are encountered as show a modified anatomical structure of the lower part of the root, up to a depth of about 15—20 cm (Fig. 1). In the subsequent years, owing

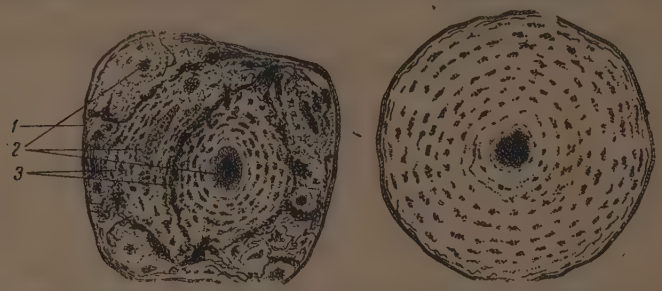


Fig. 1. Typical and modified anatomical structure of one-year-old root of kok-saghyz: *1*, cork; *2*, pith; *3*, laticiferous vessels containing rubber

to selection, the modified anatomical structure became more conspicuous in the progeny. Similar facts of modified root structure have later been observed by other plant breeders (2, 3).

In connexion with the formation of this character, we should cite here the observation made by Lipshitz (4) who said that in some roots of wild-growing kok-saghyz from natural habitats «the xylem is found to be scattered in small areas at different points of the bark». The influence of cultivation conditions and of selection thus went to enhance the development of this new anatomical character of root structure.

In 1941 we discovered new data which shed revealing light upon the biology of plants endowed with a modified anatomical root structure.

Part of the large roots sorted out in autumn 1939 were planted in spring 1940 on a plot and grown for seed. In summer 1941 the two-year-old plants were dug; many of them showed variously modified roots. In some cases the upper part of the structure of the mother-root had the appearance of «spread fingers», each of the «fingers» bearing at its tip a stem structure of the caudex type. The latter served as a base for one or several rosettes.

Especially illustrative are such cases where the tissue disintegration was so complete that instead of the single mother-root a bundle of separate independent roots was dug out. Sometimes such differentiated roots are linked by thin «cross-pieces», which makes it evident that the mother-root has really disintegrated into several daughter-structures. Similar observations were made also in 1942 on new material of two-year-old seedlings planted in spring 1941.

When the two-year-old plants (sown from seeds in spring 1941) were dug in 1942 at the breeding nursery, there have been sorted out such roots whose external surface consisted of an interlacement of thin rootlets inosculated with the body of the mother-root (Fig. 2). No cases of complete disintegration of the mother-roots into separate branches could be observed among the two-year-old plants grown on the plot from seeds.

In 1943 observations were carried out on the behaviour of two-year-old plants, when planted out under different soil conditions. Young seedlings pricked into

small pots filled with a mixture of clay and humus were planted into ground on the twentieth of May, 1942; a part of the seedlings were planted out on a plot with podzolized soil, another part on a plot with manured dark-coloured soil of meadow-swamp origin. The latter is, as a rule, much more fertile than the former and has a considerably higher moisture content. The plants have been left for another year to yield seeds.

Fig. 2. Coalescence of new internal roots with the body of mother (two-year-old) root

Fig. 3. Total disintegration of a two-year-old root of kok-saghyz into independent individuals. To the left, a one-year-old root with a typical ribbed surface. To the right, a disintegrated root of a two-year-old plant. *1*, bases of the rosettes

In 1943 some of the plants from the two plots were dug and found to be strikingly different. Those from the podzolized plot had roots of the usual aspect typical of a seedling culture, *i. e.* with a short thickened main root and vigorous branching. The roots of those plants which had been grown in dark-coloured soil looked quite different. Out of the 133 plants dug, in 88, or in 66 per cent to the total number, the roots were found to have completely disintegrated into separate specimens; in the remaining 45 plants (34 per cent) only the thickened upper part of the total root was found to have disintegrated into finger-like root-structures. Quite frequently instead of the single plant planted a year ago we dug out a whole bunch of separate plantlets (from two to twenty four) with small rosettes and thin rootlets (Fig. 3). On rare occasions these roots bore a common cork-rubber sheath.

All the plants which have formed as a result of the disintegration of the root had caudices bearing the bases of rosettes. The average number of caudices per plant was 15, the maximum number was 49, and the minimum, 2.

It may thus be stated that the variations in the size of the root which are brought about by the process of intraradical differentiation based on a modified anatomical structure, are also associated with a different abundance of the leaf: as a rule, the plants which have the biggest roots with a modified anatomical structure have many rosettes towards the second year of their life.

The sharply pronounced morphological variations in the structure of root in kok-saghyz may be interpreted in the following way.

During the first year a latent process goes on within the root, which consists in the formation in the cells of the secondary bark of separate foci of cambium producing independent vascular bundles and a bark tissue containing laticiferous vessels. The total increase of the area of the cambial tissue ensures a rapid growth of the bark of the root as a whole. Aside from this, a corresponding increase in the number of laticiferous vessels and a close packing of the latter secure a high

rubber content in the tip of the root, irrespective of its thickness. A distinctive external feature of this phase of growth of the root is its slightly ribbed surface and, frequently, the pronounced sharply tapering shape of the root.

According to the environmental conditions; either by the second, or by the third year of life (the latter refers to most of the forms which display the character just described) some of the plants show further differentiation and disintegration of the root tissues. Under the conditions of moist fertile soils rich in organic matter; cork tissue is formed inside the root around each separate pith-bark system. The common cork sheath which invests the root bursts. the bark parenchyme between the neoformations dies away and the latter emerge in the shape of separate roots, bearing leaf-rosettes.

Not all of the anatomical features of this phenomenon have been studied as yet, but two possible types of variation may be supposed to take place. The one is the intraradical branching; as a result of which only the tip of the root is subject to disintegration; or else the internal branches coalesce with the body of the mother-root (Fig. 2). The second type of variation consists in an independent formation of cambium rings; which leads ultimately to a total or a partial segregation of the root into separate specimens.

Thus; we are facing here a peculiar way of vegetative propagation of kok-saghyz; where a mother-plant is transformed after a definite period of time into a group of independent plants; *i. e.* into a natural clone.

Botanical literature contains records of modified anatomical structure both in stems and in roots of plants. Van-Tiegem (5) has described an «anomalous» stem structure in some creeping *Sapindaceae*; as being due to the separation of the cambium layer into individual sections.

De Bari (6) describes a similar anomaly of the roots of *Convolvulaceae*.

Richter (7) reports of a case of the formation of adventitious cambium and subsequently of «stemlets» within the stem of a common lime-tree.

Meyer (8) describes intraradical branching in *Aechmea Weilbachii* and *Billbergia rosea* of the family *Bromeliaceae*. In this case «the secondary roots are growing within the roots of the primary ones in a direction parallel to the axis; and often make their appearance at the tip of the root only».

According to data by Korsmo (9); the tip of the main root of *Rumex acetosa*, having achieved its development; separates into several parts which are strongly spread asunder. In the literature available there is no information as to a total separation of the neoformations and disintegration of the mother-root into several independent individuals as this takes place in kok-saghyz.

The development of a new biological property in kok-saghyz opens an infinitely wide prospect for the breeding of large-root varieties cultivated during one year. It may easily be assumed that if the thickness of the root depends upon the number of individuals it is composed of and upon the thickening of each of them; there will be theoretically no limitation for the increase of one-year roots of kok-saghyz; without impairing thereby the rubber content of the plants. In order to be able to control the new biological property of kok-saghyz; the urgent task of the breeder is to inquire into the cause of the variation in the anatomical structure of the root and into the dynamics of this phenomenon.

All-Union Institute
of Rubber Plants.

Received
6.II.1944.

REFERENCES

[1] B. Rudenskaya, C. R. Acad. Sci. URSS. XXXI, № 9 (1941). [2] Д. Н. Филиппов, Яровизация, № 3 (1941). [3] Г. И. Попов, Доклады ВАСХНИЛ, 11—12 (1942). [4] С. Ю. Липшиц, Новый каучуконосный одуванчик *Taraxacum kok-saghyz*. 1934. [5] Ван-Тигем. Общая ботаника. 1895. [6] А. Де-Бари, Сравнительная анатомия вегетативных органов явнобрачных и папоротниковых растений. вып. 1, 1877 [7] A. A. Richter, C. R. Acad. Sci. URSS. XXII. No. 5 (1939). [8] L. Meyer, Archiv für wissensch. Botanik (1940). [9] E. Korsmo, Unkräuter im Ackerbau der Neuzeit, SS. 7, u. 341, 1940.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

EXPERIMENTAL MORPHOLOGY

THE CHORDOMESODERM AS AN INDUCTOR OF THE EAR VESICLE

By R. KOHAN

(Communicated by I. I. Schmalhausen, Member of the Academy, 12.XII.1943)

It has been shown by numerous studies concerning the organizing centre that when the lip of the blastopore, *i. e.* the chordomesoderm, is transplanted into the blastocoele of an early gastrula; as a result of the inductive action of the implant there arises a secondary neural tube. In many cases ear vesicles are also induced along with this secondary medullary tube. In such cases the induced medullary tube assumes the shape of the medulla oblongata.

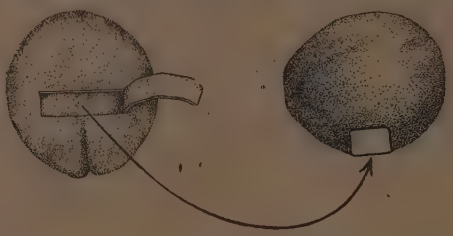
However; these experiments left without answer the question whether the ear vesicles are induced by the implanted chordomesoderm or by the medulla which has arisen under the influence of the latter. If we assume that the chordomesoderm is the inductor of the ear vesicles, then it must induce the medullary tube and the ear vesicles directly, but if the latter are induced by the nervous system, the process of induction is achieved in a sequence: in the beginning originates the neural plate induced by the chordomesoderm and this in its turn induces the ear vesicles from the adjacent ectoderm. The experiments referred to above make it evident that ear vesicles may arise from the thoracal epithelium under the influence of an inductor, whatever it may be an implanted chordomesoderm or a secondary neural plate formed under its influence.

For my studies on the induction of ear vesicles by the medulla oblongata I have chosen a host stage different from that taken in the experiments with an organizer, which I have mentioned above. I grafted the medulla not into a gastrula, but under the thoracal epithelium of an initiating neurula [stage 13 according to Harrison ([8],[9])]. At this stage the ventral ectoderm, as it has been demonstrated by Machemer ([1]) and Mangold ([2]) for the triton and the amblystoma, loses its ability to form nerve tissue. My experiments are; strictly speaking, analogous to Spemann and Mangold's ([3]) experiment on assimilatory induction, *i. e.* induction of the neural tube caused not by chordomesoderm; but by a fragment of the nervous system, of an embryo of a more advanced age. The only difference was that I used a strictly delimited region of the neural tube, the presumptive medulla oblongata of the various stages of the neurula and grafted it not into the blastocoele of an early gastrula; but under the thoracal epithelium of an initiating neurula, *i. e.* of a stage at which the nervous system cannot be formed. My experiments show that the ectoderm of the initiating neurula having lost its ability to answer the inductor's action by forming nerve tissue; still retains its reactive capacity, but reacts to the inductor, in our case to the medulla oblongata, by the formation of ear vesicles instead of a nervous system.

It follows also from these experiments that the medulla oblongata is able to induce ear vesicles. This fact is established by the induction of the ear vesicles in the thorax, *i. e.* that they arise in a region in which normally no ear vesicles may develop and where they could arise only under the influence of the graft. In the case

of induction in the thorax the possibility of a regional influence on the host's part is excluded, and in those experiments in which the induction was achieved on the ventral side of the embryo, the possible influence on the part of the host's axial system has been reduced to a minimum.

However, these experiments, though demonstrating the ability of the medulla to induce ear vesicles, did not give any answer to the question, whether in normal evolution the ear vesicles really arise only under the influence of the rudiment of the medulla. We find in the literature on the question indications made by



some writers, poorly grounded, it is true, that ear vesicles may be induced by the cephalic mesentoderm ([4], [5]), by the roof of the archenteron, including the mesentoderm ([6]).

Being already certain that the thoracal epithelium responds to medullary induction by the formation of ear vesicles, it seemed to me desirable to decide with the help of a direct experiment by grafting the part of the chordomesoderm underlying the medulla under the thoracal epithelium of the initiating neurula, whether the chordomesoderm is able to induce ear vesicles.

I utilized for these experiments embryos of *Triton taeniatus*. In several cases axolotl embryos were used as donors. The stage chosen for the operation was stage 13 according to Harrison, *i. e.* that of the initiating neurula. The presumptive posterior brain was removed (see figure). At this stage it is already easy to discern the presumptive chord lying along the dorsal side in the shape of a thick band not yet separated from the entoderm and the mesoderm.

I grafted a piece of the chordomesoderm, underlying the presumptive posterior brain, under the ventral epithelium of another embryo of the same stage of development. The graft developed into a chord with somites lying on its both sides. In a series of operations of another type I transplanted chordal and mesodermal material separately, chordal material together with that of the entoderm into one embryo and the material of the presumptive somites, into another. I was able to achieve some positive results which make it possible to draw some preliminary conclusions as to the inductive capacity of the chordomesoderm.

In four of the positive cases the implant and the induced ear vesicles lay both on the ventral side of the embryo, but not at the level of the host's ear vesicles. As local influences on the part of the host are possible in this region, I do not consider these cases as sufficiently conclusive for establishing the fact of the possibility of inducing ear vesicles by the action of the chordomesoderm. It is probable, however, that the influence of the host's medulla and of the underlying chordomesoderm is insignificant at the ventral side of this region.

I consider as more conclusive the three other positive cases in which the induction was obtained in the thorax, *i. e.* in a region where ear vesicles never arise normally and where they could develop under the influence of the transplanted chordomesoderm only. These latter cases permit to draw the conclusion that the chordomesoderm as well as the medulla is able to induce ear vesicles.

I shall describe here one of these cases (No. 69) in more detail. The operation was done homoplastically on *Triton taeniatus*. Both the host and the donor were of stage 13 according to Harrison. The chord with its entoderm were used as graf-

ting material, while the mesoderm was implanted into another embryo. The graft developed into a chord and gut and lay at the ventral side of the embryo between the anterior and future posterior limbs. Two ear vesicles were induced which lay between the chord and the epithelium. They differed but little in their degree of differentiation from the ear vesicles of the host.

In those cases where the chord was implanted together with the mesoderm, the induced ear vesicles lay always alongside of the chord. It is quite possible that the so-called «leading part» in this induction belongs to the chord. Ear vesicles were never induced by mesoderm in my experiment, but I must admit that the number of experiments with the implantation of the mesoderm alone was very small. I shall not draw therefore any final conclusion in regard to this question and limit myself for the time being to the more general conclusion concerning the inductive capacity of the chordomesoderm.

These experiments prove that not only the medulla, but the chordomesoderm underlying it is able to induce ear vesicles.

If a bit of the chordomesoderm underlying the medulla is transplanted under the epithelium of an early gastrula, it induces in it not only ear vesicles but the nervous system as well, as this is known from the classic experiments with the organization centre. At the stage of the initiating neurula the ectoderm, having lost its ability to respond to the action of the organizer by the formation of a nervous system, is yet able, as my experiments have shown, to respond to this action in another way, *viz.* by the formation not of the nervous system but of ear vesicles.

Experiments with the transplantation of definite regions of the nervous system and of the chordomesoderm, *viz.* of the presumptive medulla oblongata and of its substratum, under the epithelium of an initiating neurula have, unlike the experiments by Mangold ([7]) on the transplantation of the same material into the blastocoele of an early gastrula, demonstrated nothing else, but that the age changes of the ectoderm find their expression in a changed formative response to similar sources of formative influence. Thus, ear vesicles can be induced in an unusual site not only by the medulla, but by the chordomesoderm as well.

Further investigations should show whether there is any difference in the formative influences proceeding from these two sources.

O. I. Schmalhausen ([10]) reports of cases pointing to the possibility of the formation of ear vesicles at their normal site after the elimination of the medulla at an early developmental stage. Similar indications are to be found also in communications by Harrison ([5], [11]).

We certainly have to deal here with a complex formative apparatus, the individual component of the formative action of which should be subjected to a detailed study in further experiments.

The possible variety of the formative apparatus, deviating from the classic example, the eye-cup and the lens, the complexity of formative influence and formative response, have been pointed out by D. P. Filatov ([12]).

Received
12.XII.1943.

REFERENCES

[1] H. Machemer, Roux' Archiv, **126**, H. 3 (1932). [2] O. Mangold, ibid., **117** (1929). [3] H. Spemann und O. Mangold, ibid., **111** (1927). [4] J. Holtfreter, ibid., **133** (1935). [5] R. G. Harrison, Anat. Record, 64 (1935). [6] H. G. Albaum and H. A. Nestler, Journal of exper. Zoology, 75 (1937). [7] O. Mangold, Naturwissenschaft, **21**, H. 43 (1933). [8] R. E. Kohan, C. R. Acad. Sci. URSS, XXIII, No. 3 (1939). [9] P. E. Коган, Ученые записки МГУ, вып. 43 (1939). [10] O. I. Schmalhausen, C. R. Acad. Sci. URSS, XXVIII, 276 (1940). [11] R. G. Harrison, Anat. Record, **70**, Supp. 3, 35 (1938). [12] Д. П. Филатов, Журн. общ. биол. ,II, № 1 (1941).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLV, № 1

EXPERIMENTAL MORPHOLOGY

DEVELOPMENT OF BONE TISSUE IN PURE CULTURES OF OSTEOGENIC MESENCHYME *IN VITRO*

By A. RUMJANTZEW and L. BEREZKINA

(Communicated by I. I. Schmalhausen, Member of the Academy, 17.I.1944)

In a series of our papers ([1]—[3]) concerning the problem of histogenesis of the ground substance of cartilagenous and bone tissues, we endeavoured to obtain the development of typical bone tissue by prolonged cultivation of pure osteogenic mesenchyme growing histotypically. In all the successful cases of prolonged cultivation we obtained, in the centre of the explant, a fibrous structure resembling bone tissue, but not once were we able to observe the transformation of mesenchyme cells into typical osteoblasts and the development of true trabecules.

The study of the corresponding literature shows that similar results were also obtained by other authors ([4], [5]), some of whom were inclined to consider these tissue formations as a typical bone. Nevertheless, by a careful study of the illustrative material attached to these works, it is easy to ascertain that the tissue developing in the centre of the explanted pieces represents the result of hyalinisation of collagenous fibrils rather than a real bone structure. At the same time typical bone tissue, as a rule, always develops in cultures from various rudiments of the skeleton, as has been described by many authors and has also been often observed by us in our laboratory. Continuing our attempts, we found ourselves able to obtain the formation of true bone tissue from osteogenic mesenchyme growing histotypically, calling forth no objections.

We performed our experiments in the following way. Pure strains of osteogenic mesenchyme were isolated from the tissues of the sacral region of a 10 to 12-day-old chicken embryo. By suppressing cell proliferation in these pure strains, we succeeded in obtaining the bone formation in the centre of the fragments. For this purpose the proliferating zone of the fragments was cut away. The cutting away was repeated every 3 days during the period of a month. In such prepared cultures, as a rule, the central area gradually becomes more thick and dense. As a plasma medium was used the plasma of an adult cock with the extract from the bone and muscular tissues adjacent to it. The extracts are prepared from bone of a 15-day-old embryo.

Gaillard pointed out that in order to obtain osteoid it is necessary to begin by adding extracts of younger embryo and then arrive at older ones. He used an extract of 4, 7, 10, 15 and 17-day-old embryos.

It should be noted that this procedure seems to have no essential importance. In our experiments we always used an extract from the limbs of 15-day-old embryos, diluted approximately three times, and invariably obtained a marked growth area and differentiation of the cartilage, as well as the development of structures similar to bone; it has previously been described that in fragments cultivated in this manner, after several transfers, a thickening of the central

part of the explant may be observed, while the sections taken from such cultures show the presence of a newly formed cartilage.

Usually, as the central part thickened, the growth area diminished. After the 10th transfer a noticeable spread of growth of the central part set in, in the shape of well formed dark nodules. In one series of such strains, after the fragment had been sectioned, we found in some of them a characteristic tissue resembling chondroid tissue, and along with it a typically developing bone substance (Fig. 1).

The chondroid tissue had a peculiar shape. In a poorly coloured ground substance cells of various shape were situated. At the periphery of the chondroid

Fig 1. General view of a 3-month-old culture of osteogenic mesenchyme after 2 months of cultivation by the method of preserving the central part of the bit. Above, chondroid tissue of a rounded type; below, typical bone tissue wedging into it

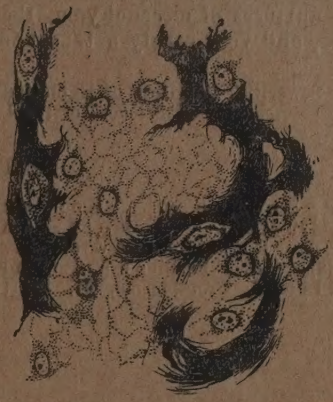


Fig. 2. Trabecules on a section from the same culture; great magnification. Between the trabecules are seen osteoblasts represented by cells with small appendages

tissue, in its ground substance there appeared collagenous fibres taking on bright blue when stained after Azan's method. Their number increased gradually, and approaching the very periphery this fibrous tissue became more compact. This thickened part was connected with the typical bone trabecules deeply stained with water-blue.

Along the periphery of the developed bone structure of irregular shape, at the side of the fibrous tissue, one could see typical osteoblasts bordering upon the lamina of bone substance. These cells have characteristic short processes and a slightly basophilic protoplasm, with a rounded nucleus. The cells of such type were seen among separate trabecules (Fig. 2).

The trabecules themselves were thickened, and a fibrous structure was observed along their edges only.

As there was no sharp transition between the chondroid and fibrous tissues, on the one hand, and between the latter and the bone tissues, on the other, it could be concluded that in our culture a simultaneous development of cartilage and of bone took place from osteogenic mesenchyme.

At the same time, we did not see any direct transition of the bone tissue into the cartilage. Even in the place where the bone tissue was wedging into the cartilage, there remained a sharp boundary line between them, and what is most interesting, not a single osteoblast was observed in such places.

The bone tissue described was undoubtedly formed in the culture, since we were very careful that our pure cultures prepared by the classical method should not contain any thickenings in the centre.

Thus, from a simplified, growing cytotypical mesenchyme, by transferring it to the conditions of a retarded growth, it is possible to obtain the development of a true bone. The simultaneous development of both bone and cartilage confirms, first, the indications that the skeletogenic tissue is bipotent, and secondly, that the skeletogenic tissue, notwithstanding its simplification, preserves its potential, according to its determination in ontogenesis, as has been pointed out in our previous works.

Unfortunately, our experiments do not allow us to solve the question why, when explanting rudiments of a developing bone taken from an embryo, a further development of the bone always proceeds and its new formation in the sketetogenic mesenchyme which forms the zone of growth; whereas when explanling pure cultures of mesenchyme, there chiefly develops a cartilage or a bone-like tissue, and very rarely a true bone, as described in this paper.

A. N. Sewertzoff Institute of Evolutionary Morphology.
Academy of Sciences of the USSR.

Received
17.XII.1943.

REFERENCES

[1] Румянцев и Л. Березкина, Архив анатомии, гистологии и эмбриологии, 27, 179 (1937). [2] L. Berezkina, Bull. Acad. Sci. URSS, série biol., No. 2 (1943). [3] A. Rumjantzew and L. Berezkina, C. R. Acad. Sci. URSS, XX, No. 9 (1938). [4] A. Fischer u. R. Parker, Arch. f. exp. Zellforsch., 8, 297 (1929). [5] P. Gaillard, Protoplasma, 23, 145 (1935).

Prix $ 0.50